Motorways and the rural environment

G. D. SPEARING & M. R. PORTER

Sir George Taylor, Director, Royal Botanic Gardens and Chairman, Landscape Committee, Department of the Environment

I know the infinite pains to which the Department of the Environment goes in its efforts to find a precise line which will have the minimum harmful effects both on people and on places. While it would be absurd to pretend that motorways can be built without hurting anyone, the many who benefit remain silent.

55. Most engineers, no doubt, regard a motorway as finished when the contractor leaves the site or when it is opened, but to those of us who are concerned with motorway planning a motorway is never finished, because the planting will take many years to mature, going through many phases in the process. Throughout this recurring process the way in which the grass and planted areas are maintained has a very pronounced effect on the appearance of the motorway and its impact on its surroundings.

56. Maintenance rarely receives the attention it deserves. Grass is usually thought of as nothing more than a cheap and easy way of covering waste ground, and a nuisance in that it has to be cut and kept in a tidy state. This, I believe, is a negative attitude. I should like to see a reduction in the amount of closely mown grass which in excess leads to dull uniformity. I favour a rougher texture to give a more natural appearance to the road verges, and to encourage the introduction of native plants.

57. As a botanist, I know the growing importance of motorway verges as nature reserves. An interesting survey was carried out by the Nature Conservancy in 1970 on various stretches of the M1, and close scrutiny of the vegetation showed that native species were coming into the reconstituted embankments. There is no doubt at all that there is a distinct possibility of the motorways becoming sanctuaries of fine populations of native plants—sanctuaries, of course, because no one is allowed to picnic on these slopes and pick the plants.

58. I welcome the setting up of the new Department of the Environment, and I am confident that it will live up to its name, particularly in matters affecting road building. Under the present regulations, the civil engineering contractor who is tendering for a motorway contract is left to find his own sources of fill material needed for construction, and this, of course, leads to his quoting on the basis of the cheapest available source consistent with obtaining planning permission. Opportunities to rehabilitate dereliction in the form of slag heaps may be missed because if they are not the cheapest source of suitable fill they are likely to be passed over; a hole may be dug when an ugly hill might have been removed. This is an example of the difficulty of achieving full and free co-operation between separate Government Departments and between Whitehall and local authorities.

59. There has, I know, been some encouraging new thinking in Wales where there is suitable fill material, for instance old coal mine tips, reasonably near by. The contractor is sometimes asked to give alternative prices in his tender, one for fill from a source of his own choice and one from the preferred source. If the latter is more expensive, the Derelict Land Unit of the Welsh Office is given the opportunity of paying the difference out of the funds which it has available for landscape reclamation. This gives better value for money which, after all, has to come out of the same pocket. I hope the Secretary of State for the Environment will give this scheme some thought,

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particularly in the new roadworks planned in the Black Country where so many blemishes could be removed.

Miss S. Crowe, Past President, Institution of Landscape Architects

Only a week ago I had the very great pleasure of driving down part of the M6 and I consider that from a landscape point of view it is a magnificent job. The eye just takes it quietly without any jar whatever. Probably the general public who go through will not realize at all what is being achieved. If it is done well enough, it is not obvious, but those of us who know what is involved realize what a lot has gone into the really beautiful land shaping and the treatment of the banks.

61. I know, by the way, how difficult this question of sloping the banks is. It cannot always be done and it is not always easy to put the land back to agriculture; but I would like to report that the sheep are enthusiastic. They were grazing on the cuttings down to the fence, because obviously the grass seed that had been put on the cuttings is a great deal better.

62. I hope that this will not be a 'one off' but will be taken as the norm for all roads, although, of course, one knows that there are some points that cannot be copied in other places. It is not always possible to get vertical separation, but I would like to say that I think the centre strip is perhaps the weakest point left to be sorted out in the landscape of our roads. If the safety fences are erected down the middle, I shudder to think what the result will be. Britain has now shown the rest of the world that it can make roads as well as anybody else. Having done that, I think we must raise and widen our sights to get a much better co-ordination between the design and siting of motorways and the rest of the planning procedure. Planning a visual corridor should be common practice, but there is also a tremendous effect on different parts of the country when a motorway goes through them.

63. Some parts of our landscape are too precious to have even the most beautiful road run through them and I think we should make up our minds to this. I also think that there are other landscapes which are too fragile to take all the people who will be brought in by the new roads. For example, I would very much like to know how much planning and thought are being given to what will happen to Ullswater and that part of the Lake District when the hordes which will be let loose at the beginning of next summer come into that region, which is already balanced on a knife edge of being over-used. I do hope that the new Department of the Environment will bring together all these different aspects of planning and tackle this very difficult question.

64. Finally, may I once again say how immensely encouraged I am to see this splendid result of a real co-operation between the profession of engineers and our much younger profession of landscape architects.

Mr J. K. M. Henry, Scott Wilson Kirkpatrick & Partners

Perhaps the best thing I can do is to illustrate some of the principles which the Authors refer to and which our organization incorporated into the building of the Lancaster-Penrith Section of the M6.

66. This section of motorway is 36 miles long, and one of its attractions lies in its frequent, and sometimes dramatic, changes of scene. From Carnforth it follows the coastal plain, then climbs up the side of a valley onto hilly fells in the vicinity of Killington Reservoir, drops down to cross the railway and swing into and through the Lune Gorge to Tebay; it then climbs over wide open fells to a summit near Shap and finally descends through a patchwork of stone-walled fields to farm and parkland.

67. The Authors speak of the advantages of keeping constant gradients on major climbs, and of stepping and separating carriageways. There are two major climbs of about 450 ft on the route, and in each case the climbing carriageway has a constant gradient, of 1 in 40 in one case and 1 in 50 in the other. On the climb up the side of

Fig. 5. Landscape at Borrowdale

Fig. 6. Cut slopes in Lowther Park

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a valley to Killington there are two lengths of stepped carriageway, and on the steep sidelong ground through the Lune Gorge the carriageways are stepped for $3\frac{1}{2}$ miles with a vertical separation of up to 30 ft. To the north of Tebay the smooth contours of the fells and their low agricultural value permitted separation of the carriageways. The maximum width of separation is about 800 ft and access to the land between is provided to enable it to be grazed. The carriageways come together for the summit and separate again on the run down to better farmland. In all there are 6 miles of stepped carriageways and $7\frac{1}{2}$ miles of separated carriageways.

68. The mountainous nature of the topography helped to provide natural bridge sites, and the large features of the landscape matched the scale of the motorway. A few areas required special landscape treatment, such as the crossing of Borrowdale (Fig. 5), a side valley leading into the Gorge, where the motorway bridge runs alongside a masonry viaduct carrying the railway. For the most part, the motorway route followed the topography closely, and called only for attention to detail.

69. The traditional form of fencing on the fells is in post and wire, and in order to make this as inconspicuous as possible a fence was designed with slim steel posts coloured olive green in place of the normal timber posts. The new type of fence was laid for two-thirds of the length of the motorway.

70. A main objective was to flatten the slopes of the earthworks and, by bringing the fence line in close to the motorway, return the land to the owner. Lowther Park is a good example (Fig. 6). On leaving the park the motorway cuts through a hillock and then crosses a deep wooded ravine. This cutting provided a close and cheap source of fill material and, to obtain the required quantity, its slopes were flattened to 1 in 4 and subsequently reverted to parkland. Another opportunity for flattening slopes resulted from the need to streamline the motorway in areas exposed to drifting snow. Streamlining was introduced wherever possible on the exposed fells north of Tebay, and the fencing was brought in close to the motorway. Elsewhere some shallow cuttings were 'day-lighted'. I agree with the Authors that normally it is not economic to flatten the slope of a deep cutting, but I wonder whether a case could not be made for flattening a proportion of it, and perhaps bringing the fence line off the skyline.

71. The Authors refer to the use of spoil to help landscape the earthworks. It was used quite extensively for moulding the ground at the ends of bridges, particularly on the coastal plain, and for flattening fill slopes.

72. An unnatural feature of earthworks can be the sharp angle at the change from cut to fill, and to overcome this we provided a minimum width of grass slope of 20 ft so that there is a gradual roll over from one slope to the other.

73. The countryside on this length of motorway is particularly beautiful, and considerable efforts were made to avoid damaging it while at the same time allowing motorists to enjoy the views. Service areas will face outwards, away from the motorway and overlooking the countryside, while for 5 miles through the Lune Gorge and its southern approaches there is no overbridge to obstruct the very beautiful view of the Gorge's eastern slopes.

Mr R. L. Wilson, R. Travers Morgan & Partners

Mr Spearing described a two-stage study for route location: first a primary location to determine the general route of the road, and second, more detailed studies taking into account various factors including environmental cost. I consider that too much is attempted at one time and that a three-stage study would be better. First, the network should be designed on traffic grounds: having established the points to be joined by a link in the network, a traditional route study for the link can be carried out taking into account all the various factors, including a broad environmental assessment. This should be followed by a third stage, a line study to establish the best line for the route selected in stage two. By omitting a detailed line study, much opportunity for good landscape design is lost.

75. On the environmental factors it is now possible to measure noise and visual intrusion in various ways. It is also possible to value environmental factors by studying people's behaviour and attitudes in different environments. Much of this work is based on house prices and householders' values, i.e. it is related to the resident and of limited application in valuing the quality of the environment of those areas enjoyed mainly by visitors. There is a scope for further research into values put by the community on environment: this would be based on a study of choice situations where the least cost solution has not been taken because of environmental considerations.

76. The Paper referred to the importance of knowing farm boundaries in routing a motorway. However, information on farm boundaries is generally only available to assess severance after the route has been selected: if farm boundaries were known over an area during the route study then the route could be selected bearing in mind the need to minimize farm severance. At present, any general information on farm boundaries is based on data collected during the war and is of little value today.

77. Finally, I should like to turn to the question of the impact of motorways in increasing the accessibility of some of the choice rural landscapes to people in urban areas. This is a very serious problem which I can illustrate by reference to the Conway and Colwyn Bay area of North Wales: this area will be affected by an improved A55 route which will link the North Wales coast and Snowdonia with areas of high population in Liverpool and Manchester.

78. An analysis of the existing (1966) and future (1986) pattern of day trips for leisure purposes to these areas shows that the reduction in journey time to the area from 30 to 20 min from nearby Rhyl results in the doubling of a number of trips/day per 1000 cars owned (i.e. taking into account changes in population and car ownership). More dramatically the reduction in journey time from the Manchester area from 2½ to 1½ h results in a four-fold increase in the day trip rate.

79. This is the problem to be faced when a motorway network is extended into the rural areas, providing access to areas of high amenity value. I do not think the answer is not to build the motorways, which are required as a proper part of our strategic network. Some control of use of existing amenity areas is inevitable and indeed is already taking place: a more positive step would be to create new areas which will compete with the traditional amenity areas. It must be recognized that an increasing number of people will want to make an increasing number of leisure trips but there is no need for them all to be made to the traditional places. There are many opportunities for the development of new recreation areas, for example the disused gravel pits: only if these opportunities are taken now will the pressure be taken off the traditional areas which are being made more accessible by our rapidly expanding motorway network.

Mr A. A. Osborne, Consultant to G. Maunsell & Partners

Having had the pleasure of collaborating with both Authors in the past on the subject of the Paper I am glad to have this opportunity of raising some points.

81. I cannot entirely agree with the Authors' remark that the flattening of sideslopes (§ 22) can seldom be justified on economic grounds, particularly if such landscape excavation works are taken into account before the final design or policy on the earthworks balance. For example, I know of a case a few years ago when a proposal to flatten a cutting sideslope to open up a view of a wood at the top of the flatter slope would have provided much needed good material filling to the extent of 40 000 cu. yd by the wood and 100 000 cu. yd elsewhere, and would have saved the high cost of imported material. I feel that this is not an example of the Compulsory Purchase Order (CPO) objection mentioned by the Authors, but an engineering requirement not easily met by alternatively changing a vertical alignment which was at minimum depth to suit the key bridge clearances. Would the Authors agree that in such cases, the engineering requirements could overrule the CPO difficulties?

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82. Loutzenheiser,⁴ dealing with changes of highway design to reduce traffic hazards, included a firm proposal to flatten embankment sideslopes from the normal 1 in 2 to 1 in 6 according to the height of the embankment. These proposals would also be welcomed from a landscaping aspect, but I feel they are unlikely to be adopted in Britain at present.

83. I am particularly interested in the reference in §§ 18 and 19 to the use of separated carriageway levels, sometimes also described as grade separated carriageways, stepped carriageways or split-level carriageways. The example quoted and shown in Fig. 1 is, as mentioned, rarely possible except in hilly country of low agricultural value, but the principle applies and the same effect to a lesser degree is possible in undulating lowland of higher agricultural value, providing that a minimum difference of level of 5 ft can be achieved. At this difference in effective height the increased width on central reserves, except on minimum curves requiring extra width for visibility, is 23 ft 6 in. The Authors mention several important traffic advantages of such landscaping but omit reference to the elimination of headlight glare by such a natural antidazzle barrier.

84. The horizontal and vertical alignment geometry for such separated carriageway levels necessitates a minimum length depending upon the particular vertical alignment. Consequently in a location having a series of adjoining sidelong ground spurs with embankments in between, such as occurred in the Coldra-Crick length of the M4, the stepped carriageways were carried across the embankments and through some cuttings to provide long lengths, with the low hazard and traffic amenity advantage mentioned in the Paper. The Authors may be interested to know that there may be accident reduction cost benefits to this aspect of landscaping, since the Gwent Constabulary Traffic Accident Statistics continue to show that this section of road, having almost half its length in stepped carriageways, has the lowest average figure of injury accidents per mile for Monmouthshire in the three year records, being 1.2/mile for 1969, a figure that is improving and is much better than that of the adjoining motorway.

85. Points of interest are raised in § 23; the suggestion for lowering the fence from the verge level to the embankment on flattened sideslopes to avoid restricting the view is a good one and would also indicate that some views from a motorway would justify raising the carriageway level to above the top of the fence level by extra filling.

86. On the subject of planting I observed on a tour of northern Californian Free-ways the use of planting to conceal or camouflage unsightly parts of structures, retaining walls and slip-road approaches, and such use of evergreen planting has not to my knowledge been used in Britain. The examples are the concealment of retaining walls or columns approaching an overbridge at an acute skew to the motorway, tall shrubs at the top of the cutting slope on slip-road approaches, and what may be quite singular, the concealing of the central pier of a girder type overbridge with the shrubs of the central reserve or median, as they say, increasing gradually in height within 30 or 40 yards of the bridge pier to reach the level of the beam soffit at the bridge, giving an impression of no central pier.

87. I am glad to see reference to the desirability of a type of fence lighter than the standard timber fence. There is also reference in § 27 to the desirability of a smooth fencing alignment, but this can only be achieved if license areas are included in a CPO for excavating or filling beyond normal motorway boundary limits and to include extended transverse culverts or land drainage.

88. The principle of using trees as mentioned in § 37 is sound, but for trees to be effective, they must be high enough. Am I correct in assuming that such trees would never be planted on a verge or embankment sideslope? I am very conscious of this 'killer' aspect of the use of tree trunks for alignment guidance because as a young engineer I was responsible for setting out tree planting on the Guildford By-Pass as advised by the Roads Beautification Committee, the forerunner of the present Landscape Advisory Committee. One of these trees many years later was responsible for

the death of Mike Hawthorne, a local racing celebrity. Only the use of very slim mature tree trunks or high shrubs will avoid the danger of this road 'furniture' hazard. Under the heading of trees I should mention that they are used in California as underbridge delineators on the adjoining embankments because the bridge is an area of restricted movement or one having no recovery area—an expression used to describe normal latitude for vehicle movement.

89. With regard to consultation with the local authorities mentioned in §§ 26 and 43 does the Authors' mention of consultation at an early stage imply that the present Advisory Committee may play a secondary role in the future? I feel that uninformed elected members of local authorities can only comment at a later stage, however, if the work of both highway and landscaping specialists is not to be handicapped.

90. No mention has been made of the real need for very early use of the Local Planning Authority's powers to prevent tree and hedge clearance by farmers when the motorway is being constructed. The changed shape and area of severed plots offers a ready incentive for farmers to remove early existing hedges, individual trees and copses to obtain larger plots. In spite of there being no mention in the Paper of the need to use these tree preservation powers I must acknowledge the prompt co-operation I have had in the field from Mr Porter on this aspect.

91. The section on bridges (§§ 33 and 35) is incomplete without reference to the use at some locations of an appropriate facing to abutments and wing walls to match the environment, particularly when vistas are provided.

92. The choice of the type of a structure within a large family of bridge types mentioned by the Authors should not be entirely governed by standardization economy. I have in mind an accommodation bridge where the approach spans were steeply inclined as a substitute for an embankment. This reduced the height of the side road approach embankments but presented a stark silhouette on the skyline of relatively flat countryside. Which of these alternatives would the Authors have preferred?

93. In California the use of 'weathered steel' or 'Corten', as it is known in Britain, for crib retaining walls, normal fencing and tensioned guard fencing supports, is now advocated because it is a material that blends well with the countryside and therefore has landscaping advantages. One outstanding example was the use of the Armco Bin-Type Crib for a wall retaining a ranch road high on the sideslope of State Route 24. The heights of the wall ranged from 5 to 31 ft over a length of 440 ft and the gaps in the 'weathered steel' cribs were filled with grass and flowers which formed a most effective camouflage.

Mr R. J. Bridle, Midland Road Construction Unit

I would like initially to say that any opinions that I may express will be my own and not necessarily those of the Department of the Environment.

95. The Authors have given admirable practical advice to the designer, but I would have liked to see some space devoted to quantitative techniques of amenity evaluation. Amenity benefits or disbenefits are those not specifically accounted for in the economics of trip making arising from the impact of highway works in the environment of non-trip makers. Route selection is generally carried out by producing an economic and an amenity ranking for a number of alternatives. Where these rankings differ, then amenity evaluation is necessary in order to make a choice.^{3,5,6}

96. The problem of measuring the value lost or gained by the public whose environment is disturbed by the rural motorway is a difficult one. I should, therefore, like to refer to some attempts, first at ranking and second at quantification possibilities.

97. The first is an amenity ranking method used in the Oxford-Birmingham

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Fig. 7. Landscape values

Feasibility Study. The work was carried out by Oxfordshire County Council for the Midland RCU. This is a simple method of overlays, where transparent maps are shaded in various gradations to represent one or more of the important areas for preservation for various variables such as historic area and landscape value, etc. Agriculture has been included as a variable although dealt with in land costs, since it is considered to have an amenity value in its own right. This is not without challenge, and clearly double counting can occur in the analysis if more of one kind

Fig. 8. Cumulative effect of most severe restrictions

of variable is included than another. Fig. 7 shows landscape value in three gradations, making up the corridor, Fig. 8 the accumulated values. There is very little difference from the landscape effect, although many variables were taken into account.

98. On later schemes we have made a variation of this and multiplied the length of road through each category by a weighting for that category. Summation of the weights and division by the total length will give an amenity index by which the alternatives may be ranked.

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99. The problems not resolved by these methods are:

- (a) the variables are chosen subjectively and double counting is thereby difficult to distinguish;
- (b) the method may compare the amenity quality of various corridors but not the impact of major works in them;
- (c) a ranking only is produced and no monetary value is assigned which can be used to compare with the economic ranking.

However, the method does help to add some additional evidence to the otherwise subjective advice obtained from the Department's Landscape Advisory Committee.

100. Another technique which we have used in the Midlands is attributable to the Coventry, Solihull and Warwickshire Sub-Regional Study Group. In this technique the corridors are divided into kilometre squares. Each kilometre square is treated separately in respect of two variables, landscape and intervisibility. The landscape value arises from 26 variables. Subjective scores were given to a number of squares, and regression analysis was carried out in order that on later occasions there was no need to measure it subjectively. The intervisibility factor is created from the number of other squares seen along each side of the square under consideration and modified by the slope of the square itself. If these two factors are multiplied together they give a factor which produces an amenity valuation or a ranking between values. This method again suffers from the same problems as the previous one, although it is much more sophisticated. Nevertheless, it provides some consistency, and is therefore worth developing to deal with motorway impact.

101. I should like to suggest some future possibilities of quantification not yet attempted but which could have the advantage of leading to a monetary evaluation. The Authors touch upon the effect of motorway networks on land use patterns and also refer to the importance of accessibility change in its measurement. At present this effect can only be treated speculatively and theoretically, and further information needs gathering.

102. One possibility is to establish control zones so that, by home interview and traffic census, generation and attraction may be determined for each zone together with a complete row and column of the distribution matrix at given points in time. The control zones would be in pairs of like character, but one zone of the pair would be chosen so as to be relatively unaffected by growth stimulated by accessibility changes.

103. Several possibilities arise once the theoretical basis of traffic behaviour has been reinforced by observation. With the hypothetical example of a control zone with one land use only, it is possible, by the derivation of the perceived cost of travel, to imply the value that the users assign to its use. Minimally it is at least equal to the cost of getting there, but not all the trip makers would be at the margin. The maximum assigned value could be taken to be the highest cost of trip made, while other trip makers in each cost category could be assumed to be uniformly distributed between that value and the marginal trip cost of their category.

104. It is not practical to use zones with one land use only, but trip making by purpose would be observed, and comparison of control zones and knowledge of the total value of several land uses will enable interpolation of unit values for use in cost-benefit analysis.

105. Many land uses are, of course, not measurable by trip making, for example, the supply of water or power or sewage disposal. Nevertheless, these studies are important for traffic modelling and would yield some values indicating an order of amenity cost. The studies should, therefore, be considered in depth and put in hand as soon as possible.

Mr E. P. Hinkley, Group Engineer, Warwickshire County Council; Midland Road Construction Unit

I, too, must say that any opinions that I express are my own and are not attributable

to either the Warwickshire County Council or to the Department of the Environment.

107. Before asking the Authors to comment on the complex problem of paying the price of safeguarding Britain's heritage, I should like a little more information on land acquisition and planting programmes. The Authors state in § 22 of the Paper that land cannot be compulsorily acquired for amenity treatment in connexion with highway works. I should like to know whether the Authors are aware of any established cases where compulsory purchase orders have been published for land for amenity purposes and subsequently withdrawn. The debate on this point seems to centre round what is meant by the construction of a trunk road and whether this can include adequate amenity treatment as an integral part of the road's construction.

108. With regard to bringing the countryside closer to the driver (§ 37) how does one achieve a balance between presenting an interesting view and distracting the driver, and how essential is the driver's view of his surroundings when to a large extent the foreground is taken up by other vehicles on the road? Would there be some advantages in concentrating expenditure on planting embankments and some cutting slopes which are visually intrusive to the local inhabitants and deferring treatment of cutting slopes seen only by drivers until a later point in time? After all, the driver gains immediate benefit in terms of time and accidents saved and could forgo the visual benefits for a few years.

109. I should like to discuss for a few moments the wider problem of assessing the value of the environment in relation to motorway proposals. It has been suggested, at one end of a scale, that certain areas such as National Parks should be designated as areas where no form of public or private development will be permitted. At the other end of the scale most forms of development would be permitted, subject to normal planning legislation. I consider this to be an ideal aim, but I venture to say that it will take time to define such areas, particularly in the middle range of the scale.

110. For a new motorway proposal it is possible to put a price, in highway terms, on avoiding, say, recreational parkland by calculating the extra constructional and capitalized travel costs, but where a substantial extra sum is involved it should be considered if that extra sum, or part of it, may perhaps be better spent by providing more recreational parkland elsewhere. At present it is possible to combine capitalized travel and construction costs to evaluate alternative lines for a motorway in a financial analysis, but I think it is questionable whether one can set these costs against amenity in a cost-benefit analysis. One simple aspect of this can be illustrated by considering the apparent increasing value set on leisure time. This will require the relationship between recreational travel costs and construction costs to be monitored in some way.

111. Whilst the necessary studies and research are going on to try to express amenity in, or partially in, monetary terms, I hope the motorway programme will continue, and I suggest that there are already some data which will enable the Government to grant funds specifically for the environment. There are cases where motorway proposals and other forms of development have been modified or withdrawn as a result of amenity objections following a public inquiry. These decisions may have been taken on a somewhat subjective basis, but they do imply that it was worth spending more money to protect some elements of the environment. The additional costs may be made up from extra construction costs, extra travel costs where a longer route is involved, and the continued congestion suffered by deferring the improvement whilst the alternative route is being processed. I suggest that it should be possible to examine these cases and set down what has in effect been paid as a minimum to protect certain features of the landscape. Similar data could also be derived where a strong amenity case has not resulted in modifying the route to indicate a maximum amenity value. Such an evaluation can only be done, in my view, where decisions are essentially related to the ventilation of informed public opinion through an inquiry or an appeal.

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112. By relating these implied extra costs to a synthetic landscape model or sieve-map analysis, it should be possible to assess what might be paid over and above the norm in order to avoid or minimize effects on other similar areas elsewhere in the country. It might be held that the environment was not properly assessed in past decisions and therefore the derived costs would be disproportionately low. I do not believe that past decisions were so very wide of the mark, but more importantly, a method on the lines described could provide at least an intermediate, if not permanent, system for assessing the size of a national environmental budget and a means of justifying a grant from that source for particular schemes. I would be grateful if the Authors could comment on this proposal and say whether, to their knowledge, any such exercises are being attempted.

Mr D. J. Gregg, A. M. Voorhees & Associates

Would the Authors please clarify my impression that present examples of separated carriageways were permitted solely on grounds of cost of construction, that is omitting any estimate of accident savings or subjective justification? Would they agree that the route design process tends to make the nature of the topography change in a gradual fashion rather than suddenly, along the centreline? May I suggest, therefore, that the point of transition, where conventional construction gives way to separated carriageways, can only be optimized if the capitalized discounted values of future accident savings are taken into account. If credit were given for accident savings, I believe that the carriageways would remain separated for a longer stretch of the transitional terrain.

114. At present the accident savings from separated carriageways can only be guessed at. The elimination of cross-median collisions is only one of several considerations. Benefits can be expected from the consequent improvement of night driving conditions, night accident rates on rural motorways being currently about double the day-time rate, relative to traffic levels. Other reported difficulties which result from narrow central reservations would be avoided, for example loads being shed from one carriageway to the other and accidents being 'reflected' from one carriageway to the other merely by visual contact.

115. Figures 9-11 illustrate my belief that whenever separated carriageways can be justified on initial cost grounds alone, then it may be expected that a greater length of separated carriageways would have been justified if the accident benefits had been included on a capitalized basis.

116. Imagine a length of motorway which crosses a section of difficult terrain where the estimates show that separated carriageways are justified solely on construction cost grounds. In Fig. 9 the axis OX represents the centreline of a length of the motorway so that the origin, O, is situated on the difficult terrain and the outer point, X, lies on basic terrain, with a length of transitional terrain between them. (The terms 'difficult', 'basic' and 'transitional' are used in a loose fashion to indicate the nature and the direction of the gradual variation of topographical difficulty along the motorway centreline.)

117. The vertical axis OY represents values (OB) of the construction cost saving/km, resulting from a decision to build the length OA in separated carriageways rather than in conventional construction. The curve MNP is the continuous function which in general will exist, being defined from all possible values of OA and the resulting values of OB. From these definitions, it follows that the area OBNAO represents the total saving in £ achieved by building a length OA of separated carriageways rather than in conventional construction throughout. (The curve MNP could be defined by making a series of cost estimates to define general points MNP directly, but it is possible that the curve could be synthesized from consideration of the topographical variation itself as a continuous function.) If the designer optimizes construction cost alone, he will make the transition from separated to conventional

Fig. 9

Fig. 10

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construction at a point A which maximizes the area OBNAO, the overall construction cost saving.

118. Figure 10 introduces an axis OZ, which represents values (OD) of accident savings/km, resulting from a decision to build the length OA in separated carriageways rather than in conventional construction. In Fig. 10 it is assumed that the accident saving is equal to OD regardless of the length OA, i.e. the accident savings curve DEF is a horizontal straight line. The accident savings are drawn as a present value of future savings, discounted to the base year, i.e. future accident savings are *capitalized* to a basis compatible with construction cost savings.

119. If he has this information on accident savings for the traffic using the scheme, the designer should maximize the area OBNAEDO.

120. The important point at issue is that the value of OA which makes OBNAO maximum is *in general* not the same as that which makes OBNAEDO maximum. This is apparent from consideration of the way in which the various rectangles in Fig. 10 change their size as different values of OA (say OA') and OD are chosen. (However, it is possible to illustrate the point mathematically by assuming that the curve MNP over the relevant range has the equation of the negative exponential decay function, $y = me^{-kx}$, which may be reasonably appropriate as a terrain-cost model in the present context.)

121. In Fig. 11, it is assumed that the capitalized accident saving/km increases in some relation to the length over which separated carriageways are constructed, and the problem is then to maximize rectangles of the general form OB'N'A'E'D'O.

122. It is apparent from Fig. 11 that if the accident saving does in fact increase

Fig. 11

in some such manner, then it will become an increasing justification for separated carriageways over the transitional terrain, whilst the construction cost differential is decreasing or unfavourable.

123. The general nature of the relationships illustrated suggests that the real-life decision on where to end the separated carriageways could be substantially modified if the full accident benefits were known. Accident data from the M6 and M62 will not be sufficiently representative to enable general conclusions to be drawn. What is needed is an interurban route built with separated carriageways throughout as a demonstration project. The benefits of separated carriageways are a fundamentally important issue which should be resolved for our 'second generation' motorway programme.

124. A site for this second generation demonstration project is suggested by § 49. American research has shown that many drivers will prefer to travel on an environmentally attractive highway. This could be an effective factor in securing the diversion of traffic from the M1 to the London–Oxford–Birmingham route. The Oxford–Birmingham section presents an opportunity to create a valuable demonstration project. We could call it the Shakespeare Parkway.

Mr J. A. Turnbull, Mott, Hay & Anderson

One point not so far covered is the question of noise. Whilst accepting that this is generally restricted to urban conditions, there is the problem of alignment close to villages. Moving the alignment away from the village creates a barrier which is not really used by agriculture and subsequently is developed for uncharacteristic housing. Is it not therefore better to align the route closer to the village, acquiring the intervening land and using it for landscaping and planting?

126. There have been comments about contouring and the extra cost of earthworks for flattening side slopes and returning land to agriculture. It seems to me that some money should be spent on this. One of the major objections visually is usually the sharp angles that appear at the top and the bottom of the cutting and embankment slopes: to round off these angles represents only a small proportion of the earthworks cost. Several of the earlier intersections are, with due respect to the designers, not particularly imaginative from the landscaping point of view, and more of the earthwork cost could well have been spent in landscaping the intersections without necessarily having to carry out major excavation on the intervening areas.

127. On the question of tree planting outside the motorways, I take it from § 43 that there will now be greater co-operation with local planning authorities, which in the past has not always been the case.

128. No one seems to have made any comments on § 29 which refers broadly to design requirements. Obviously one aims to get a flowing alignment, and I would ask the Authors, particularly Mr Spearing, to comment on the possibility that there will be a truly polynomial solution to both horizontal and vertical alignment in the future, so that everything flows continually through the countryside.

129. The question of parallelism has been raised in § 23 in relation to fencing. The lighter fencing which is suggested is fine in a situation like the M6, but in the more close terrain of the south of England one is required, by the requirements of the farming community for cattle protection, to provide stronger fences than those suggested.

130. The parallelism problem will be further accentuated by the introduction of the central reservation crash barrier which surely will take the driver's eye completely off the surrounding countryside; there will be a tendency for him to be mesmerized by this continual parallel line.

131. The subject raised by Mr Bridle and Mr Hinkley is one in which we are surely all interested—how are we going to evaluate the environment in economic terms? The Buchanan Report suggested a points system in urban areas, but one cannot translate this into monetary terms at present. To justify expenditure that may be a considerable percentage of the total scheme must involve an economic basis.

Mr J. W. Ward, Sir Alexander Gibb & Partners

I was much encouraged when the learned Authors of this Paper set the seal of their approval on divided carriageways. The Authors quote the advantages of a reduction of accident risk and a greater ease of snow clearance. However, in a Paper dealing with the impact of the motorway on the rural environment it is perhaps surprising that the great advantage of carriageway separation—that of halving the impact of the motorway itself and of the traffic running upon it—was not discussed.

133. To obtain the full benefit of such separation it is, of course, necessary to separate the carriageways by a distance of several miles. This is no original idea, but experience has shown that whenever this is propounded it is inevitably dismissed as causing a greater outlay of the taxpayers' money. That this outlay will be increased cannot be denied, but it would be well to examine the balance sheet. It might be possible to urge that the reduced adverse effect on the environment is worth the extra cost. I think it may be accepted without question that the effects of inserting a single carriageway into the landscape would be much less severe than those of inserting civil engineering works on the scale of a dual three-lane motorway.

134. In my opinion, the worst effect of the motorway on the environment is the noise of traffic. With carriageways separated by several miles, the noise for any one observer will be halved. It may be argued that twice as many people will be affected. However, if the noise is reduced to an acceptable level, an improvement will have been obtained. On the one hand, 2x people will only be conscious of the traffic as against x people being driven mad by it.

135. In order to obtain an idea of the increased cost of splitting carriageways it is necessary to dwell for a moment upon each operation of motorway construction. Fig. 12 indicates the two constructions which are being compared. Both are shown in about 10 ft of cut, as representing an average amount of earthworks for a long length of motorway running through easy country. It will be seen that land take is increased by approximately 50%. There is, however, one point of importance to the agricultural community which is not improved by splitting carriageways. I refer to severance. This will be doubled. Farmers living along what may be called the original line will still be severed, whether by one carriageway or two. If the carriageways of the original line are split and one moved several miles away to a subsidiary line, an additional group of farmers will be affected.

136. Referring to Fig. 12 it will be seen that the area included within the earthworks, which is a measure of the site clearance required, will be increased by about 38%. For fencing, the amount will be doubled. On drainage and services, if culverts are excluded here and included in structures, a dual carriageway motorway has three drains along its length, whereas a separate carriageway would have two. The increase is, therefore, 33%. For the 10 ft of cut taken as the average over the whole length of the section of motorway under consideration, the increase in earthworks is about 23%. For road foundations and paving there will be no increase at all. For structures it is assumed that underbridges would be increased by only two extra sets of wing walls, so that they can perhaps be ignored in the first approximation. Overbridges, footbridges, access bridges and culverts would probably be subject to an increase of about 38%.

137. The cost of providing a crash barrier in very long lengths has not yet been stabilized. Suggested figures are £12 500/mile plus £4000 for converting the central reserve from grass to a hard surface. A total of £16 500/mile seems a little high, and a rate of £14 000/mile has been assumed.

138. Table 1 shows the conversion for these various increases in cash, based upon the successful tender for a 19 mile length of motorway now under construction. The figures marked with asterisks have been calculated on the assumption that the gradients of separate carriageways will conform to the standard applied to the dual carriageway road. Like is being compared to like. This, however, is by no means necessary. Once divorced, the carriageways are a law unto themselves. There is no

Fig. 12

Table 1. Comparative figures

Operation	Rate, £	Quantity		Amount		Difference	
		1	2	1	2	Up	Down
Land take (acres)	300	28	42	8400	12 600	4200*	
Site clearance (acres)	80	28	38.6	2240	3080	860*	
Fencing (lin. yd)	2	3520	7040	7040	14 080	7040	
Drainage and services (lin. yd)	10	5280	7040	52 800	70 400	17 600	
Earthworks (cu. yd)	0.35	293 500	362 000	100 000	127 000	27 000*	
Structures: (mile)						No change	
(a) underbridges	68 600	1.0	1.38	68 600	94 600	26 000	
(b) remainder	14 000	1.0	—	14 000			14 000
Crash barrier (mile)						82 700	14 000
						14 000	
						68 700	

reason to restrict downhill gradients to 3% and they might well be increased to 6 or 7%, thus allowing the profile to follow the surface of the ground more closely, with a consequent saving of earthworks and land take and greater ease of marrying the structure into the countryside.

Mr D. J. Twigg, Donovan Lee & Partners

Quite a number of people think that a road is something nasty, which should be hidden and which is alien to the natural order of things in the rural scene. That it is

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something which is unnatural must be disputed, since the highway is older than man himself.

140. The quality of the pastoral scene is often heightened by natural meandering roads, as witness those which originated as sheep tracks in the Lake District. Present-day man can often succeed in maintaining this natural quality, and I would like to take the opportunity of expressing my admiration of the way in which the Lake District motorway is being integrated into the environment.

141. In view of the previous discussion, I shall restrict myself to two points. First, scale is of prime importance and is an objective which has frequently been neglected. Visually scale has an absolute truth, the appreciation of which remains the same today as in the times of the ancient Greek engineer architects. Second, in terms of superficial treatment, absolute truth may not exist, since our views will tend to vary from time to time, and it is of interest to reflect at this stage that from a tree planting point of view, Napoleon's roads lined by uniform rows of trees look quite natural, although it is improbable that present-day experts would advocate this type of treatment.

Mr R. W. Rose, Consultant

I think I am the only member of the ICE who is also a member of the Institute of Landscape Architects. If I am right in saying that, I think it is something which should be of concern to both Institutions because there should be many more engineers who have taken sufficient interest in landscaping to study and take the examinations of the Institute of Landscape Architects.

143. With regard to earthworks, we have gone beyond the stage of considering landscaping as being merely tree planting. Landscaping, as far as roads are concerned, is so much part of the engineering design that an engineer really has to do most of the work himself. So much of the landscaping necessary on roads revolves around the need to look for alternative engineering solutions, to find a better way of doing something which is in addition a good engineering solution.

144. Having said that, may I make one or two criticisms. First, on the question of flattened side slopes, the Authors made the point that the Minister has not the power to acquire land compulsorily for amenity purposes. My comment on that is that it is time that he got that power, and not only to get more land for side slopes. There are other occasions when land should be made available, and the power is not there to get it at the moment. Mr Spearing seems to accept only financial reasons for flattened side slopes and I feel that he has not given any value at all to the amenity problem. Is the amenity problem looked at too much as a financial problem? There are good examples of landscaping, but are these examples purely accidental? Would they have been carried out if they had cost more than what was necessary for purely engineering factors?

145. I suggest that a major construction such as a road should have an allowance of 5% built into it for amenity factors. With a major building I would expect the architect to allow something for sculpture, for example, and for factors which are not strictly speaking necessary for structural purposes. Why cannot we have an extra 5% on the cost of roads? Would it not be better to build 95 miles of good motorway rather than 100 miles which are not quite so good?

Mr D. E. Hennessey, Consulting Engineer

This Paper illustrates the interest which the Ministry of Transport has shown consistently over a great many years in aesthetics.

147. I should like to deal with two points in the Paper concerning visual aesthetics, one relating to external harmony and the other to internal harmony.

148. The Paper refers in § 17 to the need to follow closely the contours of the environment. This is not a principle which was developed in the early days by the

Fig. 13

Fig. 14

German authors of the whole art of aesthetic design. They advocated very strongly *not* following closely the contours in order to achieve what was known as a grandeur of design (Figs 13 and 14). I would welcome the Authors' comments on this.

149. In § 33 the Authors mention the interruption to the road alignment caused by overbridging, incorporating a central pier. This arrangement destroys not only the unity of the design of the road but the unity of the design of the bridge itself. This question of duality in the spanning of highway overbridges is a constant problem. The canon of number in aesthetic design stipulates that unity must exist, and this is

Fig. 15. Britannia Bridge

why the duality of span, or an even number of spans, is not acceptable unless it is modified in some way. The answer is either to omit the centre pier or to resolve the duality.

150. The principle of resolved duality is beautifully illustrated by Stephenson's Britannia Bridge which is a classic example of all the visual points in bridge design. The duality in the number of spans of the Britannia Bridge is resolved by the weighting of the piers towards the middle, and the subtle arch line joining the tops of the piers (Fig. 15) through to the terminal lions. It is a matter of concern that the visual unity of this bridge is now threatened.

Mr Barker, Consulting Engineer

I should like to make a few comments on highway engineering and, indeed, all aspects of civil engineering and the destruction of archaeological sites. Having been brought up against an archaeological background and having received a training in engineering, I find myself in the peculiar situation of being able to appreciate the problems of the engineer and the difficulties facing the archaeologist.

152. Professor Barry Cunliffe has recently stated that 'A large proportion of our primary data is being destroyed by various causes such as the regeneration of town centres, the extension of arable farming, mineral extraction and a host of other earth shifting processes.' In the 75 miles of the M5 constructed south of Strensham, at a cost of £55 million, there were two known sites which were destroyed. A further 123 sites have been discovered on the line of the motorway, and another 40 sites as a result of a field survey adjacent to the motorway. Of these, only 15 were investigated by digging. Imagine the number of sites which have already been lost due to the 700 miles of motorway already constructed where there were no observers.

153. Two points become evident from this: first, that sites are being destroyed at a far faster rate and in greater quantities than previously appreciated; and second, that motorway construction offers an opportunity to discover sites which would otherwise remain unknown for many years. If only 0.05% of the total cost of the motorway were spent on archaeological investigation, then a lot more could be recovered.

Mr R. J. M. Harrison, Senior Lecturer, Civil Engineering Design, Queensland Institute of Technology

There is one aspect of rural communities that appears to have been overlooked in the past: county boundaries. An inspection of many sections of county boundaries will show that they are also boundaries between different communities and different loyalties. Generally there are very few farms crossing the boundary; towns and villages rarely straddle it. Except where boundaries follow rivers or mountainous watersheds, they could provide the location for a motorway which is designed to minimize rural dislocation.

155. Because of the pattern of communities, county boundaries have fewer roads crossing them than do parish boundaries. Where the county boundary runs in a fairly consistent direction and over undulating terrain, an investigation would show that roads cross it on an average of 1/mile, with an A class road about 1/5 miles. This is normally fewer than is found on the motorways in Britain, hence bridgeworks

might also be minimized. Table 2 gives figures for some typical examples of roads crossing county boundaries, and it is suspected that the Rutland/Leicester, Lincoln/Leicester, and Lincoln/Notts boundaries might be of interest for an A1 replacement.

156. There would seem to be some merit in considering the location of the county boundaries before deciding on the position of any future motorway network. Admittedly, the number of counties affected would be increased with such a location, but generally the severance of the adjacent communities would be greatly reduced.

Mr H. Addison, Fellow

I would agree with the Authors (§ 37) that for the driver along the motorway '... there is so much of interest to see and enjoy—towns, villages, cooling towers, churches, quarries, factories, and most of all the endless variety of the countryside itself'. How, then, can the driver most effectively be encouraged to savour these new experiences? They cover a remarkably wide range, and since many of them are aesthetic experiences they are necessarily personal and individual ones. In this realm of aesthetics the engineer is often regarded as an intruder, at least by the artists, writers and novelists who have hitherto taken this province of feeling as their own. And indeed a journey of a couple of hundred miles along a motorway, including halts at service areas, would provide contacts with as wide a diversity of humanity as should satisfy a Charles Dickens or a J. B. Priestley.

158. Fortunately journalists are already beginning to write about the renewed joys of motoring: one of them, Mr John Charteris, recently referred in *The Times* to articles and booklets for the benefit of the motorist, suggesting that a new kind of publication might be specially devised for motorway motorists.

159. Could the Authors add their own support to such projects? Certainly the term 'motorist' should be read in a comprehensive sense, for in truth it is the traveller in the passenger's seat who can best enjoy a motorway journey. Unlike the driver, who can never withdraw his attention from the road in front and the vehicles behind, the passenger can survey the landscape in all directions, he can study his maps and guides, and he can identify and point out to the driver the objects of interest on either hand. In a north-bound car approaching the M1–M45 fork, the passenger might say quietly to the driver: 'We shall soon be passing on the left a round brick tower with an ornamental coping. It is one of the ventilating shafts for Robert Stephenson's Kilsby tunnel on the London to Birmingham railway.' Or again, further north, the passenger-guide might remark: 'This slope we are now mounting is part of the viaduct carrying the motorway over the Manchester Ship Canal. Within a few minutes we shall be crossing George Stephenson's Manchester to Liverpool railway.'

160. In any event the motorist who has taken full advantage of the aesthetic pleasures that the motorway designers and builders have opened up for him will be

Table 2. Numbers of roads crossing county boundaries

Boundary location	Straight distance	Between	Road crossings		
			Minor	B	A
Kent/Surrey . .	8 miles	A25–B2110	5	2	—
Surrey/Sussex . .	23 miles	A286–A23	11	2	3
Wilts/Glos . .	9 miles	A433–A420	10	1	—
Oxford/Bucks . .	7½ miles	A41–A421	8	—	—
	9½ miles*	A418–A41	7	1	—
Essex/Herts . .	12 miles	A120–nr A505	?	2	—

* Ignoring bulge in boundary.

? No map available to contributor.

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able to describe his sensations without any help from professional writers. Could he forget the surprise and delight of that first journey along the northern part of the M1 motorway, through open country most of the way, from which cities such as Leicester, Derby and Nottingham had been virtually spirited out of existence? And what, he would ask in astonishment, when following the M6 motorway across what people are already describing as the Manchester-Liverpool conurbation, has happened to the cities of Wigan and Warrington?

161. A more recent experience could be still more memorable—the eastbound transit of the M40 High Wycombe by-pass, when the evening summer sunlight falling on the beechwoods and the newly exposed chalk slopes formed a succession of patterns of quite distinctive beauty.

Mr L. N. Reddaway, Merz and McLellan and Partners, Australia

The Authors have presented a valuable paper which summarizes the desirable environmental features of motorway design. Some of these can be incorporated in a design at very little cost, but others may result in significant sums being spent on achieving an aesthetically pleasing result. This raises the question of how much the community is prepared to pay for preserving or even enhancing its environment. Can the Authors offer any guidance on this most difficult question? Do they have any rules-of-thumb by which they assess the monetary value of pleasing aesthetics, belts of trees, or fine views?

163. Presumably it would be possible to postulate an average sum of money which drivers would be prepared to pay each time they traverse a route if they could perceive, say, a fine view from it; this sum could then be discounted back from anticipated traffic figures over the assumed life of the motorway to achieve an extra 'present value' of an aesthetically pleasing route, over one without the fine view. Do the Authors know of any research along these lines?

164. In an hypothetical example, planning engineers might be called upon to adjudicate between a beautiful, long route with a relatively accident-prone parclo-type interchange on the one hand, and a shorter route near a foul-smelling factory, with lower unit costs, on the other. Surely it is the inherent purpose of money to compare the values of two dissimilar things, and if all design features could have their community values expressed in money terms, then hopefully the highway planning engineer would be more likely to provide the community with what it wants rather than what his own subconscious prejudices suggest.

Messrs Spearing and Porter

Sir George Taylor suggested that grass be less closely mown, and this is a matter which is under constant review. It is hoped that the botanical survey, to which he referred, will give the Department some useful guidance on how to maintain the grass areas economically, while obtaining a natural appearance and increasing their effectiveness as nature reserves. His hope that the setting up of the Department of the Environment will lead to a co-ordination of effort in the fields of road building and landscape reclamation is shared by the Authors, and is indeed a challenge to the Department.

166. Miss Crowe suggested that the central reserve poses the biggest remaining landscape problem in motorway design. The Authors, in their day-to-day work, are both involved in this problem, and their Department is giving a great deal of attention to the interrelated questions of the width of the central reserve, the provision of safety fences, anti-dazzle measures, road safety and aesthetics. Miss Crowe's concern for the impact upon the countryside, particularly its more vulnerable areas, of the hordes of motorway-borne vehicles is generally shared and is clearly a major issue facing both the Department and Local Authorities.

167. Mr Henry's comments reminded the Authors that the line of the M6 in

Westmorland was so good and the surrounding countryside so beautiful that there was a particular responsibility to avoid even minor shortcomings in the contouring of the motorway earthworks. In such surroundings they would have been far more noticeable than in countryside of average quality. There was thus no need to resort to planting to conceal shortcomings, which in treeless countryside would in any case have been inappropriate.

168. **Mr Wilson** suggested that route location be carried out in three stages; first as a link in the traffic network, then as a corridor study to enclose the link, and thirdly a detailed line study within the corridor. The Authors accept this concept and would plead the constraint of length if the Paper should have created any contrary impression. They would suggest that location is a process of continuous refinement rather than discrete stages. **Mr Wilson** also pointed out that various approaches to the evaluation of environmental factors have been made. Both he and **Mr Bridle** favour evaluation in monetary terms to enable comparison of all the factors involved in route location on a common basis; the latter also described subjective ranking of alternatives. The Authors sympathize with all these approaches but feel that none has gained a sufficient measure of acceptance to do more than narrow the area within which subjective judgement must be exercised.

169. **Mr Osborne** suggested that earthworks slopes be flattened, with advantage to amenity, where this would assist in obtaining an economic balance of earthworks. The Authors are not competent to interpret legislation, but they would consider compulsory acquisition to be wholly defensible in these circumstances, as with any other feature of plan or profile designed to afford economy in construction or operation. Indeed, § 21 of the Paper describes a similar possibility. However, compulsory acquisition for amenity alone is not regarded as possible within existing powers. Nothing in the Paper was intended to detract in any way from the work of the Advisory Committee on the Landscape Treatment of Trunk Roads, the value of which is well-known to the Authors. It was intended (§ 26) to draw attention to the possibility of securing, with the aid of the local planning authority, a coherent setting for the motorway both within and without the narrow corridor enclosed by the motorway fences, and this point is also considered in § 23.

170. **Mr Hinkley** suggested that expenditure on planting might be phased to give priority to those areas which are visually intrusive to non-motorway users. The Authors can only comment that availability of funds has not so far been a constraint on planting, the cost being insignificant in relation to the overall construction cost. **Mr Hinkley** also suggested that amenity might be valued in retrospect by reference to judgements already made, and the results be extrapolated for use in future situations. The Authors felt that the difficulty of demonstrably comparing like with like in the field of amenity made this proposal of doubtful value in application, and certainly they were not aware of any current attempt to analyse data in this way.

171. The Authors agree with **Mr Gregg** that any feature of design which is both economic, having regard to constructional and operative costs and benefits, and advantageous to amenity should be adopted. Whenever an economic justification for carriageway separation can be sustained it should, in the Authors' view, be provided. But other measures can be adopted to achieve some of the same savings in accident costs (though possibly with less visual advantage): central reserve safety barriers and anti-dazzle screens are examples. The economic evaluation must have regard to these alternatives and the environmental factors are then again matters for subjective judgement.

172. **Mr Turnbull** suggests the acquisition of land to form a 'buffer' between the motorway and existing housing, but existing powers of compulsory acquisition do not allow this and such land is likely to have a high developable value which makes its negotiated acquisition for landscaping improbable. The Authors agree that a polynomial solution to both horizontal and vertical alignment is highly desirable in the interest of achieving flowing alignment, but although much work has been carried out

to this end they are not aware that it has, as yet, reached a stage at which it could be brought into general use.

173. **Mr Ward** advocates wide separation of carriageways on plan, possibly by up to several miles. He illustrates (Table 1) that this might incur an extra cost of some £69 000/mile in initial construction and the Authors would suggest that, if traffic desire can be assumed to be bidirectional, one of the carriageways must also incur substantial user disbenefit with this system as compared with the optimum location. When applied to half the traffic on the motorway they consider that this 'cost', or loss of achievable benefit, would very substantially reduce the return to be gained from the new route, while at the same time the capital cost is significantly increased. With regard to increasing downhill gradients to 6 or 7%, the Authors would expect that the reduction in braking capability with increased gradient would lead to an increased accident rate in consequence, particularly in wet conditions.

174. **Mr Twigg** argues that scale is of prime importance. The Authors agree with his view, and indeed a lack of awareness of this is the chief criticism which can be levelled against so much of the development which violates our small-scale countryside. Napoleon's avenues of poplars, which would be overpowering in England, are visually satisfying in the larger-scale countryside of northern France which these strong lines of trees can dominate without destroying.

175. **Mr Rose** contends that engineering and economic factors predominate in road location and landscaping. The Authors, in rebuttal, would point to the involvement of planning officers, the Landscape Advisory Committee and the Department's own qualified staff at all stages from the initial conception of a route and to the results achieved, as evidence that due weight is given to environmental factors. But they would admit that there is a limit to the funds available for new road construction and that economic factors have, therefore, also to be taken into account.

176. **Mr Hennessey** asks for comments on the 'grandeur of design' claimed for the earliest German autobahnen, which were planned without regard to the now almost universally accepted principles of fitting the road to the landscape. The Authors consider that true grandeur of design is achieved only when regard is paid to scale, the road both facing the challenge of the topography and succeeding in achieving a unity with it. A road which does not harmonize with its surroundings is likely to violate land-use boundaries, to be monotonous for drivers, to be more costly through increased earthworks and to be obtrusive to people viewing it from the surrounding countryside.

177. **Mr Barker** draws attention to the importance of archaeological sites. The Authors do not differ from his view, but point to the extensive consultation which is carried out in the course of route location and which includes the former Ministry of Public Buildings and Works in the context of their responsibility for ancient monuments.

178. **Mr Harrison's** remarks are interesting but they highlight the constant need to have in mind the purpose for which investment in new roads is made; to facilitate the safe movement of people and goods. Primary location in a 'broad-band' sense is therefore determined by traffic needs and the penalty in increased user cost incurred by a route which is less than optimum for traffic is likely to outweigh considerably any saving in construction cost achieved by reducing the number of side-road crossings. If the centres of population lie within the county areas, rather than on their perimeter, then interurban routes serving movement between centres must necessarily cross the boundaries rather than traverse them.

179. In reply to **Mr Addison's** suggestions the Authors would hesitate to commend any publication which might serve to distract the lone driver. In their view the main challenge, for designers, is to make interesting views available and to focus attention upon them to relieve tedium and monotony and so enhance safety.

180. **Mr Reddaway**, in his contribution, has nicely summarized the problem of

evaluating environmental factors and the Authors remain of the opinion expressed in § 10 that in the present state of the art there are no hard and fast answers and the best use must be made of informed judgement. Mr Bridle's contribution, which mentions the possibility of assessing perceived cost by observation of trip-making behaviour, may suggest a promising avenue of research for the future.

References

4. LOUTZENHEISER D. W. New design concepts for urban freeways and rural expressways. *Proc. Int. Road Fed. Road Seminar*, Chicago, 1969, 4-19. International Road Federation, Washington, 1970.
5. SPEARING G. D. and HINKLEY E. P. Investment appraisal in the comparative evaluation of highway improvements. *J. Instn Highway Engrs*, 1970, **17** (Feb.) 11-17.
6. OXFORD COUNTY COUNCIL. *London-Oxford-Birmingham Motorway Amenity Report*. County Council, Oxford, 1969.