The reconstruction of Euston station

W. F. BEATTY & R. L. MOORCROFT

Mr Beatty

There were various reconstruction proposals for Euston prepared by the London Midland & Scottish Railway Company in the 1930s. These included several schemes, shown diagrammatically in Fig. 9, for a combined station to replace both Euston and St Pancras but the final pre-war scheme was for a straightforward reconstruction of Euston only. However, with this scheme, as with the reconstruction described in the Paper, the limitations imposed by the steep approach gradient from Camden and by the bottleneck at Hampstead Road necessitated both the demolition of the central part of the old station, including the Great Hall, General Offices and the Doric Arch, and extension to the south across Drummond Street to provide sufficient platforms of adequate length.

Mr Moorcroft

The position of the demolished Doric Arch in relation to the new station is north of the new buffer-stop line, a fact not commonly realized.

99. The importance of segregating the various types of traffic was demonstrated with a reminder of typically chaotic conditions existing before rebuilding. The method of designing for projected passenger traffic shown in Fig. 10 enabled accurate assessments to be made of space necessary to meet daily peak period demands. The approach allowed for passengers to move purposefully or to pause and obtain directions without causing congestion in the main circulating areas. Back-checking with cine-photography has now established a brief-formulation technique in use on all similar projects.

Mr R. L. E. Lawrence, British Railways Board

The interesting feature about Euston is that all the calculations except in one respect came out better than expected. The station is handling more passenger traffic and more parcels traffic than for which it was designed. A most unexpected feature manifested itself on the day the station was opened; the catering arrangements were completely inadequate and the letting of shops had to be held to turn them into additional catering establishments and bars.

101. Speaking from the management angle, the biggest problem, as is always the case in a project which must be spread over a long time-scale, was cost control. The problem from the management point of view was in keeping costs from escalating because of inflation. There are cost increases arising from changes of plan and when a project of this size is undertaken over such a long time-scale engineers have to accept it as inevitable that management will change its mind. There will be substantial changes, all of which inevitably cost money. A major problem was how often should engineers and architects be asked to revise their estimates? It seemed at one stage that no sooner had an estimate been called for than another was required, and it became unreal. On the other hand, if it went on too long, there was a frightful shock to the management and board when additional authorizations were requested which went into several figures. There is a nice balance between how often everybody should down tools and update the costs.

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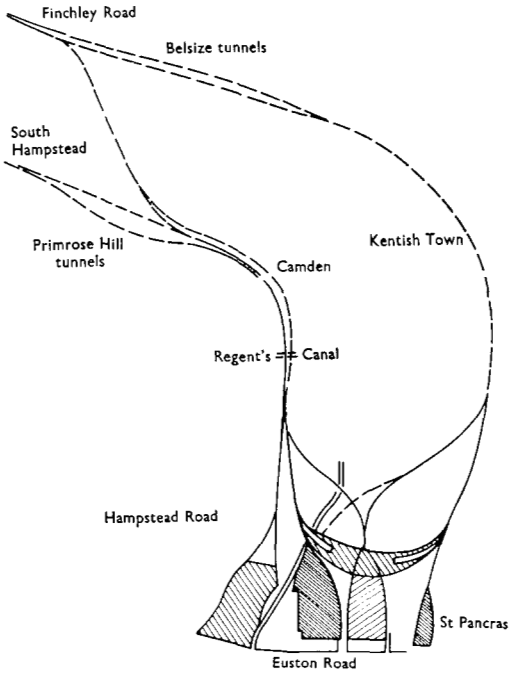

Fig. 9

Notes for Fig. 10 (opposite)

Each arrow represents one person
Spacing assumed is 25 sq. ft per person
The period taken is one minute out of the peak flow between 17.10 and 17.15
It has been assumed that the average passenger walks across the concourse at a speed of 200 ft/min
The diagram records the movement of passengers to and from the following trains:

Platform	*From*	*Arrive*	*Line*
3	Liverpool	17.10	main
9	Watford	17.12	d.c. electric
10	Bletchley	17.10	outer suburban
	To	**Depart**	
5	Birmingham	17.50	main
6	Tring	17.25	outer suburban
7	Rugby	17.20	outer suburban
9	Watford	17.18	d.c. electric
11	Bletchley	17.30	outer suburban

Another peak slightly fewer in number occurs between 17.55 and 18.00 and would result in a diagram with the emphasis on platforms 11–15 at which time each would be loading a main line train
Arrows shown thus ▲ represent the total recorded number of passengers moving across the concourse to and from the trains
Arrows shown thus △ represent: (a) passengers using the general facilities and standing in the concourse area (b) exceptionally early arrivals for main line trains

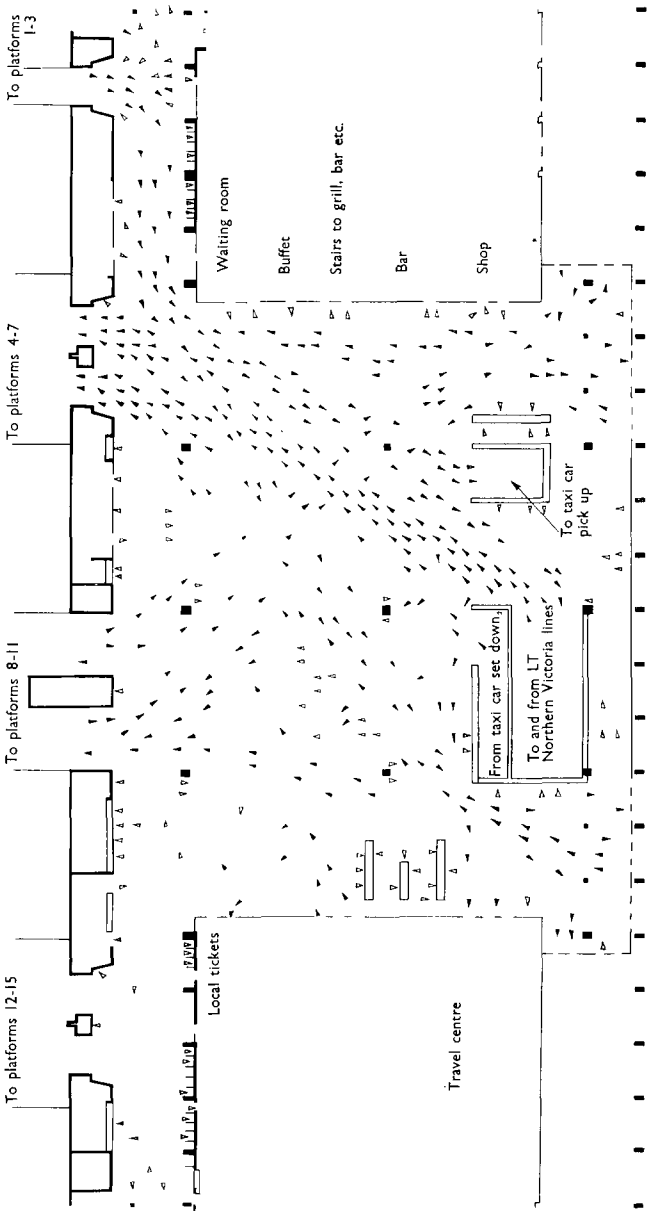

Fig. 10

102. The second point is that a major construction took place with traffic moving the whole time on the same premises; it was unique. I would not have thought it possible to have carried on business as usual as was done. There was a period when the Manchester trains had to be transferred to St Pancras and the Birmingham trains to Paddington. However, the important feature was that the commuter business was never interfered with in any way. In fact, with the simplified layout operating was rather better than in normal conditions.

103. Finally, how to manage the project had to be carefully considered, and in the end tactics were changed three times. At first, the project was managed with a management type whose main job was to provide the management brief, looking after the consequential effect upon traffic and so on. Then a change to a distinguished engineer was made, who was present in the constructional stage, and towards the end the project manager was the architect. Since this particular project I have been involved with other large projects and the argument is still going on, i.e. should the project management be in the hands of a manager or an engineer? In view of this unique experience, I should like to hear the opinion of those concerned and what they would advise.

Dr F. F. C. Curtis, formerly Chief Architect, British Railways Board

Nearly four years have passed since Euston was built, and it is a good point to look back and ask what would have been done differently if it had to be done again today.

105. In answer to that question both engineers and architects come out well. There is not enough waiting space when there are a large number of people in the station, but space costs a great deal of money. There was a lot of controversy about seats in the concourse, but a railway concourse is not a place for seats. I have found in my visits to foreign railways that the provision of seats in a concourse is an attraction for layabouts to come in.

106. Catering facilities have been referred to in § 100 and it was a pity that they were inadequate. Again, I do not think the engineers or architects had much say in this; but at Zurich, which is about the size of Cardiff, 2000 people can be seated simultaneously in the restaurant; the one at Euston has about 76 seats. It is a pity that this opportunity of making a great deal of money has been lost.

107. It was a wonderful opportunity for creating a centre for all kinds of activities. It would have been possible to have a large-scale office development over and around the station, where people could have gone to their offices straight off the railway or the buses. This was envisaged by British Rail for a long time, but it did not find sympathy with the local authorities or with the then Ministry of Housing and Local Government. It is a great pity because the site is beautiful. It is the pleasantest site of any railway station in London and it would have been a great attraction for everyone to either work or to go there for eating, or pleasure or to travel.

Mr D. H. Lee, Donovan H. Lee & Partners

I wonder whether the Authors would agree that it was only by excellent collaboration between the engineer and the architect that they were able to proceed without tiresome setbacks.

109. When I read the Paper I began to wonder whether there has been a similar project. Here is a railway station with 15 platforms and traffic, not as heavy as say Waterloo, but nevertheless quite heavy. Trains were kept running all the time. I cannot think of a similar project involving a station with that number of passengers and 15 platforms being reconstructed.

110. Regarding the refusal of planning permission to use the sky-rights over the new station, when I saw the pictures Mr Moorcroft showed of what it would have been like if it had gone ahead in 1935, I thought it would have looked splendid. However, now the station has been built I should like to ask the Authors whether they

would care to comment on what they visualize will happen, because it is realized that this was a mistake. There should be a big development over a railway station; it keeps traffic off the streets, and reduces the density of pedestrians. I should like to ask whether the position is that any major development now must be to the south between the new station and Euston Road, and would the Authors agree that it might give an opportunity to do what has been done in, say, Montreal, to introduce two long subterranean arcades so that people coming to Euston Road Metropolitan Line could do the journey under cover. However, whereas in the centre of Montreal and New York there is no dearth of people, perhaps it would be difficult to let rather expensive shop accommodation in a subway situated in the Euston area.

111. I noticed the Authors' mention of the use of a layer of plastic sheet to prevent clay in the low area being continually fed with, and softened by, surface water flowing down the gradient. It seems that too many opportunities are lost elsewhere of saving future expensive maintenance by preventing water going into the clay, particularly under railway tracks.

Mr G. G. Fordyce, Taylor Woodrow Construction Ltd

No mention has been made of the initial bold scheme for the reconstruction of Euston which formed the basis of Taylor Woodrow's participation. After many years of preparation by British Rail, proposals were sought from various contractors for the rebuilding of Euston. The Taylor Woodrow proposals negotiated in 1961 with the Chief Engineer, Midland Region, Mr Arthur Butland, involved not only the design and construction of the station redevelopment but also the provision of 800 000 sq. ft of lettable accommodation which would have made the new rail terminal viable as an entity. I am sure it is a matter for mutual regret in retrospect that it was not possible to provide these facilities because of difficulties with planning authorities.

113. The Contractor's essential task of carrying out the project while maintaining the vital train, taxi, parcels and passenger traffic, together with their attendant facilities, necessitated the closest liaison with British Rail staff. Considerable temporary accommodation had to be provided for operational purposes and moved from time to time throughout the Contract period. Demolition was undertaken immediately adjacent to railway working and passenger areas, and construction work done at varying levels both above and adjacent to the new electrification system being installed. The restricted working on the platform and track bays both in time and area made the task of manpower and plant organization a challenging exercise. The need to work simultaneously in different parts of the station and utilize common facilities while obviating the considerable counter attractions, made the disciplining of operatives a recurring task.

114. The planning of demolition and construction was a joint exercise between Taylor Woodrow and British Rail engineers throughout the Contract duration. To assist this end, critical path networks embracing all railway operational and contractors' reconstruction requirements were prepared, some reaching 80 ft in length. This is believed to be one of the earliest uses of complex network programming in the construction industry in the UK, undertaken as it was in 1962. Resulting from these programmes, an infrastructure emerged upon which subsequent work was undertaken.

115. Taylor Woodrow's mechanical and electrical design for environmental services had to cater not only for passenger and operations staff requirements, but also for vehicle fumes within the enclosed areas of the BR Parcels Depot above the platforms, and those of the GPO loading docks below the main terminal building. The car parking, taxi set-down and pick-up areas located below the piazza, together with the exhausts from the LTB's Northern and new Victoria lines required extensive servicing facilities.

116. Schemes were developed by Taylor Woodrow's civil design and construction teams which enabled work to be undertaken adjacent to, above and below both the British Rail and underground railway operating areas. Typical of these was the

design for the five acres of parcels deck floor situated above the main platform area comprising structural steel columns and beams with precast concrete units spanning between the secondary steel beams. This facilitated simultaneous railway operation and construction at the two levels and was successful in execution. This same combination of structural steel columns and beams with precast concrete planks and in situ walling was also utilized on the roadway links from platform level to parcels deck, and again the method of construction enabled safe working to be done at two levels concurrently.

117. Sheet piling adjacent to the LTB working areas and around the perimeter of the car park and west wing of the passenger building was driven by the Taywood Silent Pilemaster. At an early stage piling was proceeding within 10 ft of the National Temperance Hospital's operating theatre at no inconvenience to hospital staff or patients.

118. In order to give the necessary mobility, lifting on the platforms and track bay phases of the contract was mainly by means of track or lorry mounted cranes. On the frontal development tower cranes were utilized in the main, all of which were mounted on tracks enabling them to progress from east to west across the station. A G280 standing 160 ft high with a 6 ton lift at the extremity of its 164 ft jib was used on the main passenger building, a G80 in the underground car park and a G75 in the west wing of the building.

119. In view of the labour strength approaching 1000 in the centre of London the planned aim of obviating wherever possible industrial action by consultation with the permanent officials of the trade unions paid dividends.

120. Safety in all respects on a Contract of this nature needed the closest attention by all concerned, and the record at Euston in this context is an achievement. Also, throughout the reconstruction the co-operative attitude of the general public, faced as they were with an ever changing location of facilities, assisted greatly in the task. I am sure part of this stemmed from the visual promise of better things to come as they watched the new facilities develop.

Mr E. W. Cuthbert, London Transport

First I should like to deal with the timing of the project. The planning began in 1960, at about the time detailed planning of the Victoria Line and in particular the work at Euston was going on in the LTB. An ultimatum was presented that the existing lifts which were the only means of access to the underground station would not work after 1963. That caused a request to the LMR to get permission to remove the Doric Arch and partly close Drummond Street, because the first escalator shaft which had to be commissioned before the lifts ceased to work had to be driven under the Doric Arch. I think British Rail were rather pleased about this as it helped them. It was evident that the new ticket hall of LTB would put the boiler house in the Euston Hotel out of commission and this was a help in getting the site cleared for major operations on the surface.

122. In view of difficulties in getting planning permission, LMR had been unable to say exactly how the passengers would be able to get into the new Underground ticket hall. I am sure that if both parties had known better what would happen a better interchange could have been obtained. I should like to make it clear that as far as the railway was concerned there was the fullest co-operation, and it was just beyond control.

123. The difficulties in respect of the foundation to the main line station have been outlined, and the tunnels were underneath the main line station.

124. In conclusion I would say that the LTB working site was an enclave in the middle of the main line station works, and the successful provision of access for London Transport passengers, contractors' vehicles and materials right in the middle of the main site for the station shows how good co-operation must have been.

Mr M. Harbottle, British Rail, retired

As project engineer for stage one I should like to supplement the Authors' excellent Paper by outlining some of the major problems at Euston associated with the heavy engineering work.

126. Apart from the ever present planning problems, the most difficult operation was bored piling and its design, and piling location for overhead steelwork support. The Euston stage one site had below ground the LTB Northern Line (City Branch) and Edgware Branch forming a horseshoe shape between Cardington Street and Eversholt Street; the new Victoria Line transverse to the platform ends; the original GPO pneumatic tunnel which ran from Camden to Paddington; a lampman's tunnel towards the north end of the station, and a plethora of service mains, drains, sewers and culverts, many of which were uncharted.

127. The principal bored pile parameters agreed with the LTB were pile foot clearance of 15 ft or tunnel diameter over tunnels with a crown depth of 30 ft or more from surface and loading limited to 2 ton/sq. ft, piles alongside tunnels to have a minimum peripheral clearance of 5 ft and no allowance for adhesion from crown to invert level. These requirements were met by careful tunnel surveys and surface correlation.

128. What could not be foreseen was the labyrinth of old mains and drains; consequently it often necessitated a strictly limited re-location after initial nugatory pile driving with subsequent rapid redesign of pile-head capping correlated to the structural grid.

129. Reference was made to the wide range of cohesion values on the site. Surface layer conditions also varied so widely that in determining pile scantlings the upper 10 ft was discounted for adhesion. Absolute cleanliness of the pile base was necessary, hence the introduction of the polaroid photographic device referred to in § 39. Incidentally, the luminant was a shutter-linked flash bulb and not an electric lamp as stated in the Paper.

130. In-filling of the pile stalk was done through a short trunk hopper using sulphate resisting cement concrete with a slump of $2\frac{1}{2}$–3 in. Photographic inspection showed that self-compaction with that particular slump was most satisfactory.

131. Steelwork design, fabrication and setting out was a problem. The latitudinal column grid was at 36 ft centres but departure dimensions varied considerably because of site topography.

132. The upper deck structure, of necessity, did not align with the underlying platform steelwork.

133. There was an interesting phenomenon to the MIO coating on the overhead steelwork referred to in § 29. After final site coating there was patchy discolouration on some girders and the Protective Coatings Division of BR Research were approached for advice.

134. In 1964 steam locomotives were running into Euston and it was found that in the still conditions existing in the overhead steelwork cells interaction took place between the loco emitted sulphur dioxide smoke content and 0·4% metallic aluminium permitted in the paint. This produced on the surface paint skin aluminium sulphate and aluminium chloride patches. The effect was not detrimental to the anti-corrosive properties of the paint but from aesthetic considerations, bituminous gel was substituted as a final coat.

135. Regarding the removal of the Doric Arch, the quality of the masonry workmanship was superb and the intricate cramping, back tying and dowelling would have rendered impossibly expensive any attempt to take down the structure piecemeal and re-erect it.

Sir Kirby Laing, John Laing & Son Ltd

It appears that I am in a minority, because until I read the Paper—and particularly having heard what has been said by previous speakers—I have often wondered whether

in designing Euston Station any consideration had been given to the passengers at all. Mr Moorcroft showed the sort of course that had to be tackled in the days of the original Euston Station, but I would suggest that that assault course has not much changed in the present station.

137. First, the Authors say that it was decided that the majority of passengers would arrive by taxi or public transport. I wonder whether the Authors could tell us something of the background to this decision, taken at a time when the motor-car was becoming such a general means of transport in the UK. The setting down for cars and taxis is very restricted; only six or seven vehicles can set down against the kerb at any one time, and this seems a ridiculous provision for a station of this size.

138. Having arrived at the taxi or car set-down position, consider the problems that confront the passenger. He has to walk a fair distance to some stairs or an escalator—24 stairs to be precise—with his baggage. He then has 50 yd to traverse through the concourse to the ticket office, and from the ticket office a distance approaching 100 yd to the platforms. Having got through the ticket barrier, he then has to walk down a dangerous ramp. From the end of this ramp he is confronted with another 100 yd of walking before arriving at the first useable carriage, and if he is going to the far end of the train, his walk approaches 250–300 yd.

139. Think also of the passenger who is arriving by bus. Arriving at the bus stop he has a long walk over an expanse of tarmac only to be faced by an unopenable door. Having battled his way to a door which does open, there is then the long journey through the concourse. This really is a vast space, not a small one as described in §§ 62 and 65.

140. I know that the Authors in § 90 onwards tell us something of the experience of using this station since it was built, and have shown the way in which the circulation of passengers has behaved as compared with the original planning, but I wonder whether I am an isolated example of one who finds his arrival at Euston Station a most frustrating experience.

Mr R. Tildesley, British Rail, London Midland Region

I was Assistant Divisional Manager before and during the rebuilding of the major part of the station and was responsible for forecasting the anticipated traffic requirements in light of the forseeable electrification conditions.

142. I would like to refer to the track layout mentioned in § 26. The maximum amount of flexibility was aimed at and the present layout and signalling provide for parallel working into and out of adjacent platforms except for the short platforms 9 and 10 which are used almost exclusively by DC and AC suburban services. The old station and signalling could in no way have dealt with the trains planned under electrification conditions, the problem being the arrangement of the platforms and the approaches from Camden which made it impracticable to bring trains into Euston on fast and slow lines at less than 7 min intervals. With the new layout headway was now approximately 2 min and trains could approach the platforms at a minimum of 1 min 45 s apart. This is at the maximum speed for the line which is 40 mile/h from Camden, 20 mile/h over the points and crossings at the station approaches and 10 mile/h while proceeding along the platform lines.

143. The station must be considered as an integral part of the electrification scheme and in the submission to the Board requesting authority to commence the rebuilding, it was envisaged that there would be an increase in the daytime main line passenger service of approximately 40% and a 75% increase in the suburban and outer suburban services. The success of electrification is such that at present there are nearly 50 regular trains per day more than was originally planned and looking forward to May 1972 this will increase to 60 additional trains daily. The station is capable of dealing with this increase efficiently. In the Christmas peak of 1971 when many additional trains were run express passenger services into and out of Euston averaged 90% punctual and within five minutes.

144. Passenger traffic is only one side of the business. The old Euston station was virtually 45% a parcels terminal and those who can think back cannot fail to remember the platforms stocked high with parcels and mail particularly before Christmas. A firm objective in the design of the new station was to segregate parcels, mail, and so on from the passenger, and in general terms this has been achieved. The volume of business forecast ten years ago was approximately 100 000 parcels per day. This includes bundles of newspapers, magazines, periodicals and so on, and the figure is now within a small percentage of that which was planned.

145. Little has been said about the problems during the rebuilding; on the operating and commercial side, the objective was to run the best possible service and try to retain the revenue, whereas the engineers and architects were concerned with maintaining planned progress of rebuilding at all costs and squeezing operations into the smallest possible area. Critical path analysis was in vogue and was used as a lever against the Operator on all possible occasions at the liaison meetings which were scheduled weekly when matters were progressing favourably, twice weekly in times of stress and continually when panic measures were near. There was a great deal of temporary accommodation to provide and in general minimum standards only were provided and the staff must be paid tribute in this connexion.

Mr D. W. Quinion, Tarmac Construction Ltd

In 1961 several contractors submitted design/construction proposals for a new station on the basis of an outline scheme and schedules prepared by British Rail. Supplementary proposals were submitted relating to the possibilities for commercial utilization of the site. Proposals were accepted from Taylor Woodrow for a new station estimated to cost some £10 million, and a commercial development estimated to cost some £13 million. Railway participation would enable the station to operate free of running costs or, alternatively, they would have received a new station free of charge.

147. In 1962 design work commenced by a joint team of BR and Taylor Woodrow. This team included architects, engineers, detailers, quantity surveyors, estimators, service engineers and the basis of the construction team. Numerous schemes were were prepared for an overall development, but always these were rejected for the inclusion of offices in the commercial scheme. It was clear that BR were not to be allowed to exploit the Euston site and avail themselves of its commercial contribution. The station was divided into two stages, and initially work was concentrated on the platforms and outgoing end.

148. First activities were concerned with the demolition of the original buildings, and experience showed the need to replace them swiftly. It was not possible or sensible to retain more pieces of the old station than were retained.

149. Difficulties were experienced with the old retaining walls and turntables, built with blue Staffordshire bricks with tight cement mortar joints. By contrast, major building walls were rubble filled brick skins. Relics of earlier stations were found below more recent construction. Painted metal work in places concealed uncorroded metal and in other places nothing but rust. Paint thicknesses frequently exceeded a quarter of an inch.

150. The construction of the new station was nowhere spectacular, but certain fundamentals were germane to most decisions. A concentrated use of the station by the public required attention to details and finishes. Maintenance is difficult with concentrated public use at platform level and overhead electrification. On a multiple year contract it was necessary to smooth out labour requirements.

151. It is not clear from the two platform arrangements that the configurations of the platforms are complex, and this made it difficult to limit the number of platforms out of action and still construct new platforms at the outgoing end. It also made setting out extremely difficult, and this process was not helped by the countless obstructions over the site. No process on the ground was free from interruption and

obstruction. Work commenced on some of the central platforms and access was only possible by a temporary bridge over the tracks with long ramps down. Materials were brought in by rail whenever possible. Programming and control of materials was vital.

152. It was often necessary to use public roads to gain access from one part of the site to another. This created obvious difficulties and lost time. Ready-mix concrete had to negotiate two rush hours a day with one mile journeys taking nearly an hour. On stage two mixer trucks and elevating reception hoppers were used to speed turn round.

153. Safety and security were subjects for constant attention by full time staff. It was not possible properly to separate the works and public areas.

154. Accidents resulting in personal injury were few, but unfortunately there was one fatality on the last of a series of repetitive operations. The safety assistant was busy with potentially more dangerous hazards. Vigilance can never be relaxed.

155. The programme was an important consideration throughout. A concentrated planning effort was launched by a joint BR and Taylor Woodrow team and the result of four months' study was a detailed understanding of the inter-relationships of station operations and the permissible processes and sequences of reconstruction. The network diagrams for stage one were spread over 80 yd of drawing paper. Each foreman and engineer received a computer print-out of the logic for the work which was his concern over monthly periods. The logic of the network was of constant use, although a series of policy changes affected its overall presentation which was not updated. On stages of the work the diagram was priced per activity, and the work was valued and progressed in a matter of hours monthly. Checks on valuations prepared conventionally showed agreements within $2\frac{1}{2}\%$. The latter process took ten days.

156. The contract stage was both interesting and demanding. In view of the possibilities of the commercial development the Contractors had quoted keenly. The work was broken into sections, and a target cost was agreed with BR and their quantity surveyors for each section. There were incentives for completing within these targets, and penalties for overrunning, and for failure to meet the individual handing over dates for each and every platform and facility. All these dates were met, and only a single item of remedial work was required within the many maintenance periods. The catch was the basis for agreement of rates for the final measurement of the work. Rates were the estimated site cost of doing each operation plus $4\frac{3}{4}\%$ for the Contractor's off-site overheads and profit. On much of the work this clearly left little opportunity and no margin for working setbacks.

157. Stage two was in effect a conventional contract. To execute such a reconstruction requires teamwork and smooth working relationships. BR had problems and so did the Contractor. The results show that these were overcome.

158. The commercial development envisaged office accommodation of some 800 000 sq. ft for railway personnel and others, i.e. enough for 8000–10 000 people. This could have been journey's end for over half the suburban line traffic. An immense saving in journeying would have resulted and a saving in onward congestion.

Mr F. L. Lambert, formerly Project Manager, Euston Reconstruction

Much has been said of the many difficulties which were encountered. Individually I do not think the majority of these were anything out of the ordinary but together they did present a complex problem as various speakers have already indicated.

160. Reference was made to the network programming done early on. This proved invaluable in producing a programme which enabled us to meet the target dates imposed on the project by regional management, dates which were among the most restricting external factors. Following the delays to main line electrification, when work started up again it was decided that the target date for the introduction of the new electrification services should be 1 January, 1966. As far as Euston was

concerned, it meant that by that date track, platforms, signalling and overhead line equipment would have to be completed, and any structural work over the platforms would have to be sufficiently advanced for the remainder of this work to be done while the power was still on.

161. When the work started in 1962 it was thought that further restriction of the train services in and out of the station, over and above that mentioned in the Paper, would have to be imposed if the target date were to be met, but by means of detailed planning it was found possible to achieve the target date without interfering with the proposed services.

162. Mention has been made of temporary accommodation, but the Paper rather jumps from the provision of the temporary booking office and other features at the beginning of the project in § 25 to the date when they were finally removed at the beginning of the second phase in § 46. In fact they were moved many times in the intervening period. Whenever a change was made from one phase to the next, rapid week-end working had to take place so that passengers should not be faced with an impossible situation on the Monday morning.

163. Another requirement which presented us with difficulty but which is not referred to in the Paper was that of the eleven platforms which had to be kept in use all the time, three had to have road access to deal with postal and newspaper traffic. This was a much greater problem than having a total of eleven platforms, involving the construction of temporary platforms, which had subsequently to be dismantled, thus adding to the total workload.

164. Turning to the second phase, Mr Moorcroft mentioned the preparation of the brief. I feel this is an omission from the Paper, which disposes of the matter with the words in § 47. It was not merely finalized, it was created from scratch. Thinking of the number of railway departments and outside parties who function in the new station gives some idea of the number of people who had to be helped to make up their minds! Each had the difficult problem of forecasting not merely the quantity of business for at least five years ahead, but also deciding what their organization was likely to be, what methods of operation they would be using and what sort of fixed equipment would be needed so that the architects could decide the space to be allo cated to them, and the services needed to work their equipment.

Mr B. L. Bubbers, Mott Hay and Anderson

The work on the Underground Railway in the vicinity of Euston has been mentioned and perhaps I can add one or two more comments.

166. The new LTE ticket hall is the fourth one to serve the two branches of the Northern Line at this point. The ticket hall serving the City Branch, which originally terminated at Euston and was then known as the City & South London Railway, was sited on what is now Euston House in Eversholt Street to the east of the main line station, while that to the Charing Cross Branch, then known as the Hampstead Line, was situated at the corner of Melton Street and Drummond Street to the west of the station. These were replaced by a single sub-surface ticket hall sited within Euston Station serving both lines by means of lifts and low level passages, and it is this ticket hall which I think is referred to in § 46 of the Paper, and which was replaced by the new one beneath the main line passenger terminal building.

167. A great deal of tunnelling took place beneath Euston Station between the time of the original construction of the underground lines in the early 1900s and the work on the Victoria Line. Such work included the extension in 1924 of the City Branch northwards from the old transporter chamber beneath the main line station, the construction of lift shafts and passages, and the work connected with the realignment of the City and South London between 1922 and 1924. Most of this tunnelling had to contend with the difficulties presented by the extensive lenses of the silt and sand of the Woolwich and Reading Beds which occur in this area.

168. The diversion of the northbound Northern Line which was needed to give

direct platform interchange with the Victoria Line platforms and construction of the Victoria Line in this area was done from sites to the east and west of Euston clear of the new main line station. Work on the new underground railway ticket hall and escalators connecting to the low level station tunnels was done from an area lying to the south of the Doric Arch extending from Drummond Street across the site of the Euston Hotel to Euston Square and required planned demolition of the hotel and houses to the south.

169. Work on the first of the escalator shafts from the ticket hall commenced in August 1961 at the time when the Doric Arch was being demolished. A passage from the lower concourse terminated at a 9 m dia. enlargement to the running tunnel at one end of the southbound station tunnel of the Charing Cross Branch just to the north-west of the site of the Doric Arch. When constructing this enlargement which was designed to provide improved end access to the station tunnel, water bearing silts and sands of the Woolwich and Reading Beds were encountered in the invert in confined circumstances beneath the running tunnel which had to be maintained in traffic. The water in this 3 m thick lens was lowered using vacuum well points, and all the silt was removed down to the underlying clay and the tunnel lining built off a concrete cradle. In cradling the enlargement in this way one of the factors borne in mind was reducing the possible effect of any accidental loss of ground, had any of the deep bored piles sunk nearby penetrated the lens unexpectedly. Could the Authors say whether they did experience any such difficulty in any of the bored piles to which they refer in the Paper and, if so, how they overcame it?

170. The LTE ticket hall done in trench and steel sheet piled cofferdam comprised a heavy raft and walls of reinforced concrete with roof steelwork and columns designed to support 1200 ton column loadings from the new station above, in addition to loadings from track, platform and station access roads. When excavating for the ticket hall several old wells were encountered which caused some difficulties at lower levels when they were met on the escalator and running tunnel drives. In addition the old cast iron lined horseshoe shaped railway tunnel of the Pneumatic Despatch Company was uncovered and broken out. This was constructed in the 1860s. Like so many pneumatic rail systems, it was not a success and was abandoned, but when found the cast iron lining was in perfect condition with the rails still in place.

171. The ticket hall and escalators were fully commissioned in October 1967 to serve the diverted City Branch and 14 months ahead of the opening of the Victoria Line. These major underground railway works which had to be done within the site of the main line station, which itself was being entirely reconstructed, required careful planning by all concerned, and I think it can be said that the interrelated work went smoothly.

172. In § 60 reference is made to the terminal building layout being planned so as to discourage the idea that central frontage access was possible. This was done as a result of stipulations made by the local Highway Authority. Passengers alighting from buses in the Euston Road and wishing to use the station might be thought to be presented with a daunting sight, especially on a wet day, with the station some distance away and faced with a podium between them and the terminal buildings with no readily visible means of access. Would the Authors venture to say whether they think there has been sufficient recognition of the need for good bus-rail interchange when the approach road layout to which they refer was planned, and whether any embryonic plans do exist for taking the buses off the Euston Road and bringing them close to the station front with front access provided only for bus and foot passengers, thereby improving these important interchange facilities.

Mr A. D. Michael, Town Planner, Camden

My concern is purely with the Town Planning aspects of the development, the way in which the station is fitted into the city. These views are personal and not necessarily shared by my Authority.

174. Decisions on the planning brief mentioned in §§ 47–51 were basically taken by the LCC, before the formation of Camden in 1965. Therefore, as a local planner it is possible to look at what has been built without referring to one's past decisions, and perhaps one can be more critical than is normal.

175. A station is two buildings in one. First, it has a local function—the buying of tickets, the boarding of trains, the meeting of people, shopping, eating and so on. At this level I offer no comment, except to say that traffic access and the underground taxi circulation are surely not of the highest standard. However, second, the station may be seen as a major terminus and transport interchange, a major gateway into the capital. It is at this level that the project seems less happy.

176. The provision of quick and easy access to buses for example, seems to have been given low priority: could one not have provided a bus station across the full width of the site, in place of the piazza—which will probably be so windy as to be unusable anyway, if a new tall office tower is built. One thinks of Rome's main rail station in this context, where bus interchange is good.

177. The inclusion of a parcels depot above the tracks is admirable, for if it had not been provided some three acres of land would have had to be found elsewhere. However, there are three acres between the parcels depot and the concourse, and a similar area to the north—well shown in the frontispiece. Land costs in this area are probably in excess of £300 000 per acre, and one wonders whether one's priorities are right when the opportunity offered by six acres of unused 'airspace' is not taken up. If perhaps offices and housing had been placed over the whole station in a multi-level development, as has been done elsewhere, the communities of Somers Town and Tolmers Square, now split apart by the railway lands, could have been linked together and the station may have gained as a result.

178. Also, the great Euston Doric Arch has been lost. Figs 1 and 2 show that retention of the arch would not have been possible as the tracks are now designed. One wonders how the ingenuity of the station's designers, which was ably demonstrated in the complex contract works, would have responded to keeping the Arch, if that had been the decision of their clients, BR. One wonders too whether the taking down of the Arch and its rebuilding, perhaps within the new square or even the concourse, was seriously investigated.

179. Finally, there is the question of what should be expected of main line termini. Should they be entirely geared to the passenger in the concourse, as set out in §§ 63–67, or should one also look for inspiration to the great civic character and flamboyance of, perhaps, nearby St Pancras or the station at Rome, which has already been mentioned? In these and many other cases, the station is an important focal point in the city, a landmark, and gathering place. However, at Euston the design is as yet incomplete. (Incidentally, there is no photograph of the station's front in the Paper.) New commercial development is promised, a drastic remodelling of the local roads and a subway, and this will complete the Euston redevelopment programme. Will it make it a place which is memorable and an asset to the metropolis, which has been designed *in toto* and not as a result of piecemeal decisions on the various components? I doubt it; design responsibility for the area is split between the GLC, BR and Camden, making decisions unwieldly.

180. One has to admire the way in which the Authors and their colleagues have done a complex constructional problem. One wonders whether the future stages of the project will capture people's imagination, and be a worthy addition to the Camden and London scene.

Mr R. L. McIlmoyle

The Authors, particularly in their opening remarks, give some information about previous schemes, mainly the London Midland & Scottish Railway Company (L.M. & S.) 1935 proposals, but no mention is made of subsequent schemes and proposals which conditioned or put forward some of the features of the final reconstruction.

182. The L.M. & S. Board was committed to the 1935 scheme at an estimated cost of £7 million and work had commenced on the first stage—the new carriage sheds at Willesden, and provision of alternative accommodation for the people displaced from the area between Drummond Street and Euston Square. At this time I and those on my staff were preparing alternative schemes for the new station roof and the underground car park, while the Consultant Architect, Sir Percy Thomas, in conjunction with the L.M. & S. Architects, was preparing designs for the office blocks and other buildings.

183. All this work came to a stop when war was declared in 1939, but when the end of the war was in sight the L.M. & S. developed post-war schemes to bring up to date all the proposals which had been authorized, or developed, before September 1939. It was thought there was little prospect of proceeding with the full Euston scheme immediately but as something was considered necessary an interim scheme, which retained the main central block of offices, was developed in 1945. Completion of the Willesden Carriage Shed was authorized but, because of restrictions on capital expenditure following nationalization, this was not completed until 1953, at a much greater cost than if it had been constructed in 1947–48.

184. The financial restrictions on capital expenditure during the early post-war years prevented any further development at Euston but the growing parcels traffic created such congestion that a Committee was set up in 1950 to determine how the 1945 scheme could be wholly, or partly, implemented to cover the new situation. This Committee, on which the Writer represented the Chief Civil Engineer, made a series of reports covering all aspects of the problem but the Supplement to the First Report, dated August 1950, introduced for the first time the concept of providing accommodation for the greatly increased parcels traffic on a new deck over the tracks.

185. Financial considerations prevented the adoption of this scheme but when the departure platforms were reconstructed in 1953–54 the tracks were relaid in the positions shown in the 1945 and 1950 proposals so that the overhead deck could be provided at a later date.

186. When the effects of main line electrification on Euston Station were under consideration the Engineering Departments recommended whole or partial reconstruction of the station but this was considered too ambitious and it was decided to implement the 1950 proposals. The piling of the down side parcels deck was completed in 1959 and manufacture of the concrete units had commenced when Management had second thoughts and the partial reconstruction proposals were abandoned in favour of the scheme described in the Paper. This decision to remove the central block of offices, retention of which had been the *sine qua non* of the 1950 scheme, permitted development of the parcels depot over the whole of the north end of the station.

187. This information expands that given in § 3 of the Paper and it should also be noted that the demolition of Ampthill Square Bridge had been embodied in all proposals from 1935 onwards.

188. The 1935 scheme would have provided track and platform accommodation, passenger circulation and amenities, equal to if not better than the scheme now completed. Facilities for road traffic and parcels were inadequate for present conditions but one could not have foreseen in 1935 the tremendous increase in road traffic and mail order parcels. Nevertheless, the scheme was such that these facilities could easily have been provided when need arose and London would have had a terminal which would have been more in keeping with the largest BR or the present largest BR Region.

Mr Beatty

Mr Lawrence raised a point concerning how often you ought to attempt to revise an estimate. There is a real difficulty here, but we were helped at Euston by the way in which estimates were controlled and were being updated at frequent intervals. When

it became necessary to revise estimates for Management at short notice, we could provide figures which were of real value. I think that the Quantity Surveyors did a good job at Euston in the system of control they used.

190. Mr Lawrence also made a point about keeping traffic moving the whole time, and that was obviously one of the key features at Euston. We were helped by clearing the old middle part of the station first, and providing tracks there with longer platforms. This gave something in hand to start with, so that work across the station from east to west became easier. I do not want to minimize the construction difficulties, and I am glad that so many speakers have mentioned the working problems of the job.

191. The third point Mr Lawrence mentioned concerned the management of the project—who should be the manager, engineer or architect? I think it is very important that whoever is managing should have a real appreciation of the importance of design and construction problems, and be able to exercise a sound judgement in taking these into account. Therefore, we were fortunate in having, as Project Manager, Frank Lambert, who is first an engineer, and Norman Millin, an architect, because they both had this appreciation of what mattered. They were both good at keeping clear of technical matters which they left to the engineers and architects, and both had balanced judgement on the importance of engineering and architectural considerations in relation to management requirements. Therefore, I think it is likely that an engineer or an architect should be able to give the kind of control needed by management. Although it is a money matter, I would not suggest the employment of an accountant.

192. **Mr Lee** referred to collaboration between the engineer and the architect, and I think that although there are bound to be differences of view from time to time, on the whole it was good.

193. He added that Euston was an unusual case in that schemes carried out elsewhere had been built on a new site. I think that one or two of the approaches to the station in Paris are at least comparable, and there was another parallel in the construction of New Street, Birmingham, which was almost as difficult as Euston.

194. I agree with Mr Lee that it is most important and very worth while to make a complete job of the track foundations during construction.

195. On the question of gradients, it was 1 in 58 in one short length. The average gradient is 1 in 70 up to Camden Town, and it was originally worked by stationary winding engines at Camden pulling trains up the bank.

196. **Mr Fordyce** referred to the problem of maintaining traffic and the problem of temporary accommodation, demolition and construction alongside the railway. As I said, I am glad those problems were brought out, and I have the greatest admiration for all the people who collaborated to solve them.

197. **Mr Cuthbert** mentioned the support we had been given by the LTB in demolishing the Doric Arch. (I do not remember anybody else who publicly took credit for that at the time.) I see his point, and undoubtedly it helped.

198. I agree it is a pity that we did not have our final schemes earlier, and so be able to dovetail them better. It is a long approach to the Underground ticket hall from the main line platforms, and if we had not been so tied by the changes, we should have been able to do better.

199. I would also pay tribute to London Transport for the co-operation we received throughout.

200. **Mr Harbottle** emphasized some of the site problems and I am glad he did so. As he said, a fair amount of industrial archeology cropped up in many places. He mentioned the fine way in which the Doric Arch was constructed. It would have been impossible to take it down and re-erect it piecemeal: it had to be smashed to bring it down.

201. In reply to **Sir Kirby Laing,** who was dissatisfied with Euston in general, the reconstruction had to be done in the simplest possible form. With no parallel devel-

opment one could not afford to have the passenger facilities above with escalators down to the platforms. I would not agree with his criticism of the size of the concourse; Waterloo Station is considerably larger than Euston.

202. **Mr Tildesley** referred to maximum flexibility. We mention in the Paper that a lot of double slips were put in between tracks to achieve that flexibility. It is a pity we have such a short approach to Euston, because double slips should be avoided if possible.

203. He also mentioned that there is a restriction of 10 mile/h at the end of the platforms. I hope this will be kept in mind continuously by the operating department and all drivers.

204. **Mr Quinion** asked whether anybody had ever tried to rebuild a railway station with all these things going on. I hope Mr Quinion will agree that you improve as you go along. I would endorse everything he said about safety. It was a very difficult job from that point of view. While there was that regrettable fatal accident to which he referred, I think on the whole it was a good safety record for the Contractor.

205. Mr Quinion also mentioned penalties for failure to meet dates. I would like to add that there were also bonuses for meeting dates.

206. **Mr Lambert** referred to the conflicting requirements of the Contractor and the railway operators, and to the fact that he was the man in the middle of the storm. He was a good man to have there, because he was almost completely unflappable, and he was good at explaining both points of view.

207. The problem of financial control, referred to by Mr Lawrence, was met by regular updating of estimates by the Quantity Surveyors taking account of both rising costs and changes in plans: this procedure greatly facilitated the preparation of formal revised estimates when required for Management authorization. On the question of project management it is essential that the man in charge, whatever his professional background, should be able to appreciate the implications of design and construction problems when making his judgements and decisions on behalf of management; in this respect an engineer or architect with the necessary management qualities has an important advantage.

208. Mr Lawrence spoke of the importance of maintaining the railway business throughout the reconstruction, and several subsequent speakers amplified what is said in the Paper about the planning, staging and construction problems involved. Similar problems, though smaller in scale, were met throughout the railway electrification works and at other stations, particularly at Birmingham New Street: the railway tradition of minimum interference with traffic while construction work proceeds becomes accepted by all concerned. At Euston the space cleared in the middle part of the station by early demolition of buildings was used to provide additional long platforms: this helped to compensate for the platforms taken out of use progressively as work progressed from east to west across the site.

209. Mr Lee referred to the reduction in future maintenance which can be expected from the blanketing of the clay formation under the tracks approaching the platforms. This is particularly important because of the heavy concentration of switches and crossings in this area: this concentration, which is necessary to give the flexibility in station working referred to by Mr Tildesley, is not a desirable track feature but is unavoidable because of the limitations imposed by the bottleneck at Hampstead Road bridge.

210. Mr Fordyce and Mr Quinion recalled the station reconstruction associated with development, for which the first contract proposals were framed, to provide for a joint design team composed of BR and Contractor's staff. Experience with the joint team working, first on the scheme combining station reconstruction, and development which had to be abandoned, and subsequently on the first stage of the actual reconstruction, led to a revised working arrangement for the second stage contract. In this, BR staff were responsible for architectural design, and the Con-

tractor provided a design service for structural and mechanical engineering design to BR requirements.

211. Mr Cuthbert spoke of the very necessary co-ordination on time and space of the London Transport Works and the station reconstruction: the removal of the Doric Arch at an early stage was essential for the combined programme and a separate contract for its demolition was completed before work on the station reconstruction began.

212. In reply to the point raised by **Mr Bubbers**, small amounts of water were met in a few pile boreholes but there was no difficulty with loss of ground.

Mr Moorcroft

Mr Lawrence made mention of the under-provision of catering facilities but we tend to forget that the original intention was that the hotel would open the same day as the station, and being a British Transport Hotel, it would provide supporting catering facilities to those on the station. This did not come about, and we were caught out.

214. On the question of project management, much depends on the personality of the man in charge, but there is no doubt that a reasonable knowledge of some of the interlocking problems in the design and construction stage is very important in ensuring a smooth design realization.

215. A number of speakers mentioned development potential being lost, but the problems speak for themselves. If the station had waited for development, it would not have been built yet. The current scheme under consideration, for planning approval by the GLC, includes a hotel, multi-storage garage and offices.

216. The link with the LTB in Euston Square was considered. However, it did not get anywhere. So, also, was a scheme for low level shops on pedestrian ways which would have taken people from the south side of Euston Square into the station. These proposals were dependent on road layouts which proved difficult to finalize because they are linked with road proposals outside the immediate vicinity of Euston.

217. On the question of the outcome of Euston Square, there was a joint BR–GLC working party to consider the final shape of the Square, but that depended on the final development of the site available, and not only the extra buildings, but also finalization of the road layout.

218. I could not believe that **Sir Kirby Laing** was talking about the Euston Station I know! One of our problems was to get people into the stations easily, and for those who knew where they were going, to give them a short direct access to their trains. To get buses in closely involves agreement with the road traffic people and the LTB and the conditions at the moment are still temporary.

219. Traffic which comes out of the station and doubles back on itself is a nonsense. Everybody knows that, but it will not be put right until the road proposals are finalized. There is a proposal for moving some of the bus stops in any future development, and it is a requirement that such development must produce covered access for passengers getting off buses in Euston Road and walking to the station. The station is complete but its environs are not.

220. **Mr Lambert** raised the subject of brief-formulation and a paper could have been given on that issue alone. The important lesson learned was the need for a small working unit of high individual ability who collated and presented the brief material in digestable form, who then monitored progress and oiled the administrative wheels to ensure satisfactory resolution between the various interested parties to any problems. The senior member needed authority to make decisions or make them occur and the will to use the authority. The project organization was so successful that it now forms the basis of all major railway projects.

221. The travel habits of passengers were researched thoroughly by BR, LCC (as it then was) and LTB to study flow directions and densities both current at the time of the surveys and projected. Each terminal station will produce patterns which

may not be similar to any other. The projections at Euston have been back-checked and found to be satisfactorily accurate.

222. Sir Kirby Laing indulges in exaggeration to make his points. Having arrived at a station, the shortest routes to use either front or back of a train require you to start at the centre; this implies the station facilities to be situated centrally over the platforms. Where local traffic conditions, areas of passenger generation, and the relative levels of track to surrounding roads are suitable, and development financial returns make that approach realistic, BR make use of it (e.g. Birmingham New Street). The approach would have been used at Euston, had satisfactory commercial development been allowed. In the present station, walking distances have been kept to the practical minimum and are a considerable reduction on those of the original station.