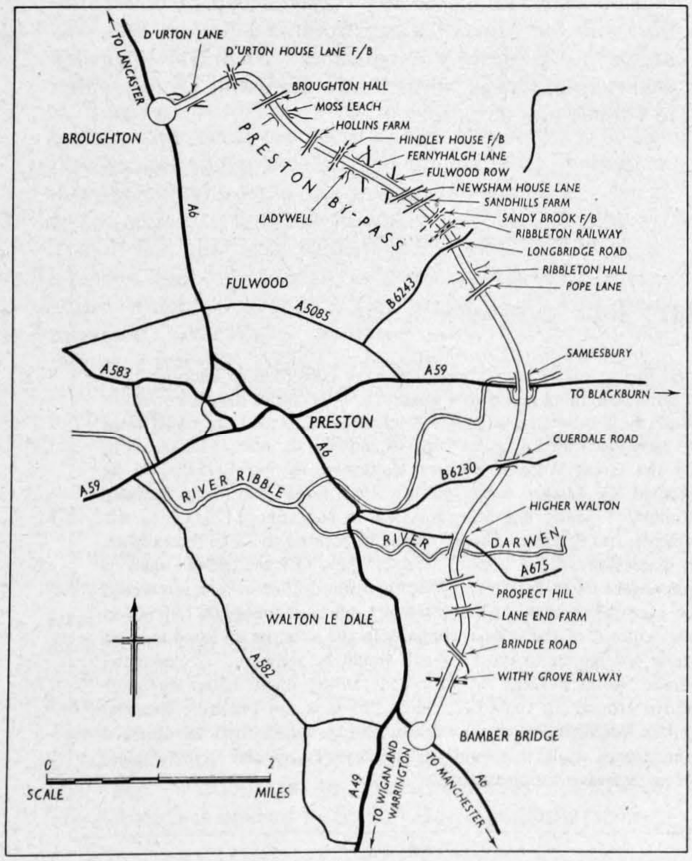
Opening of the Preston By-pass Motorway

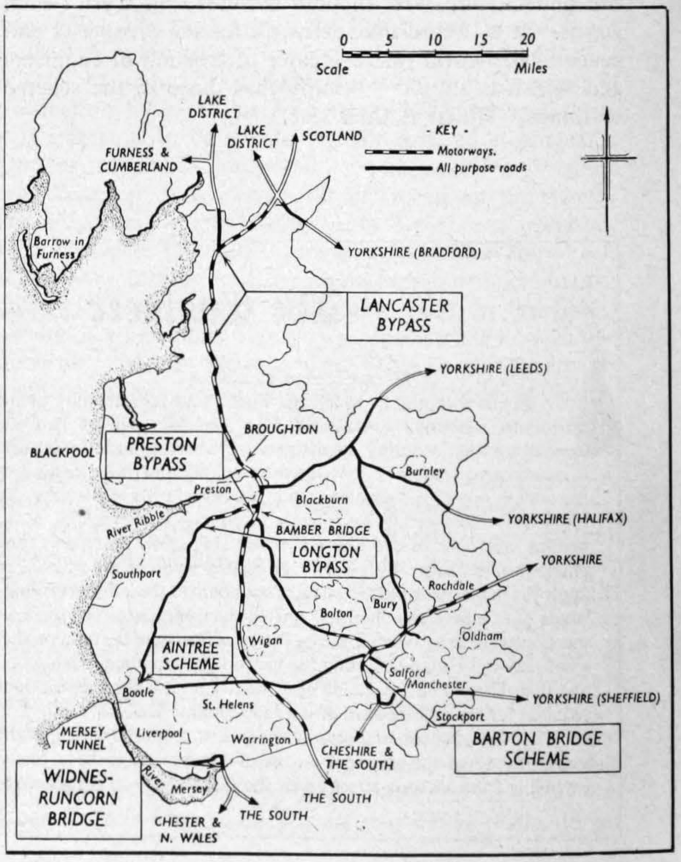
Last Friday the Preston by-pass motorway was opened by the Prime Minister, Mr. H. Macmillan. The by-pass is 8¼ miles in length, and will eventually form part of Lancashire's North–South motorway. Its inauguration is of special significance, since it is the first road in the British Isles for motor traffic only, being designed to full motorway standards. The accompanying illustration shows the view southwards along the road from Broughton Hall bridge.

BRITAIN'S first stretch of motorway, the 8¼-mile Preston by-pass, was inaugurated a week ago to-day. Apart from full motorway standards in its design, and, correspondingly, its use by motor traffic only, the road is of special interest as an achievement in civil engineering construction. This aspect of its design has also been as modern in concept as the traffic aspect, and sets out to take the maximum advantage of mechanised constructional methods. Heavy earthworks have been involved, and many bridges have been built. The road itself utilises machine-laid "premixed" water-bound macadam in the carriageways, as developed by the Lancashire County Council's engineering staff, and its basic design originated from extensive soil testing.

The road has been described as a "guinea pig"; motorway traffic signs, the efficacy of the motorway code, drivers' reactions and opinions, the necessity for speed limits, and the presence of abnormal loads are amongst the factors which will be discussed as experience of its use is gained. The Ministry of Transport and Civil Aviation will then be guided by this experience before the opening next autumn of the first major length of British motorway, the London to Birmingham route. In the ensuing paragraphs, these matters are not discussed, and in our description we have concentrated on the civil engineering works involved. The accompanying diagrams show the route of the by-pass and its various bridges in detail, and its relationship to the network of motor roads planned, or under construction, in Lancashire. Its 8¼-mile route commences at a point on the Manchester–Chorley–Preston trunk road A.6 approximately 550 yards south-east of its junction with the Warrington-Wigan–Preston trunk road A.49, passing east of Bamber Bridge to cross the River Ribble at Samlesbury about 600 yards east of Brockholes Bridge, thence by-passing Preston on the north-easterly side and terminating at the Preston–Lancaster–Carlisle trunk road A.6, 190 yards south of D'Urton Lane at Broughton. The last mile will deviate from the line of the proposed North–South motorway, into which the rest of the road will eventually be incorporated. This length is the future north link to Preston as well as forming part of the future Blackpool motorway and has been built at this stage to complete the by-passing of Preston.

The various photographs reproduced with this article give a good idea of the appearance of the new by-pass as it was when almost completed. It has dual 24ft carriageways, which may each be widened to 36ft later on, with a central reservation, 1ft contrasting marginal strips and hard shoulders, all of which is explained in detail below. The junctions at each end of the road are surface roundabouts, which will eventually be modified to form two-level junctions in the comprehensive motorway scheme, and another additional junction may also be added.





The Preston by-pass motorway, showing its bridgeworks and its relation to other motor roads projected in Lancashire

There is a U-shaped grade-separated junction at Samlesbury by the River Ribble, which is at present the only intermediate point at which access to the road may be gained.

Road Layout

In general the overall width of the by-pass is 112ft with dual carriageways 24ft wide. A contrasting marginal strip 1ft wide (the strip is of concrete, and the carriageway is "black top") flanks each carriageway, so the effective width is 26ft. The outer verges are 14ft wide, including an 8ft width constructed to form a hard shoulder abutting on to the carriageway. The central reservation is 32ft wide, so ultimate widening from two-lane to three-lane carriageways will still leave a reservation 12ft wide. The three-lane road will be needed, it is considered, for carrying the estimated ultimate traffic capacity of 46,000 vehicles daily. Continuous steel fenders are put outside the hard shoulders on all embankments higher than 20ft, on the straight, and 10ft on right-hand curves.

The design speed of the motorway is 70 m.p.h. The minimum radius of curvature is 3015 yards, and the maximum gradient 1 in 25. The maximum length of straight road is 1000 yards. All these figures generally follow quite closely the Ministry of Transport's recommended standards, though there are some minor differences. In addition, horizontal and vertical alignments have been co-ordinated with the aim of giving a pleasing effect in the landscape. The Ministry's standards are, in fact, as follows :

Straights, minimum 400 yards, maximum 1000 yards ; minimum sight line, 650ft ; minimum radius of horizontal curves, 2 deg. (2865ft radius) ; maximum gradient, 3½ per cent normal with up to 5 per cent in hilly country.

Curves of a shorter radius than 5730ft (1 deg.) are approached at each end by a transition curve, the length of the spiral being such that the rate of change of centripetal acceleration does not exceed 1ft per second per second per second. The design speed of 70 m.p.h. for super-elevations is in general developed uniformly along the length of the spiral.

The use of contrasting marginal strips as a "haunch" to the edges of the carriageway, instead of kerbs, has enabled vertical curves of very large radius to be employed, drainage gradients being unimportant as all surface water flows off the side.

Although a hard shoulder is provided for emergency use it is not intended to encourage parking along the side verges, other than at established lay-bys, sited at approximately 1 mile intervals along the road.

To economise on bridge construction, the width of the side verges at bridges with spans or widths greater than 20ft has been reduced to 4ft, plus a 1ft marginal strip. To prevent vehicles from running on to the verges at these spots there is a 6in by 12in concrete kerb for a distance of 175ft before and 75ft after the bridge.

On embankments the general overall width is increased to 118ft between tops of slopes to allow for the planting of quickthorn hedges.

The terminal junctions of the by-pass with the existing road system are surface roundabouts with a minimum diameter of 240ft. These will ultimately form two-level junctions when the motorway is continued southwards to Cheshire, and the Broughton link continued through as a motorway to Blackpool.

Samlesbury Bridge carries the motorway over the River Ribble and the trunk road A.59. The deck consists of continuous box girders with curved soffits, the roadway being carried on a reinforced concrete deck slab

At Samlesbury the junction with the Preston–Whalley trunk road A.59 presented a problem in that the "ramps" had to be wholly on one side of the trunk road owing to the proximity of the River Ribble ; the design here is in the form of a U-junction, with roundabouts of 180ft diameter on the trunk road. The trunk road and the river are parallel, and the motorway bridges over them, along the centre line of the "U," the arms of which are formed by the slip roads connecting the two roundabouts and the motorway, as can be seen in the illustration on page 917. The junctions are characterised by acceleration and deceleration lanes.

All these features, and the general standard which they imply, conform fairly closely to the Ministry's requirements, which, it can be expected, will be followed fairly closely in all motorway construction. But since the Preston by-pass is the British prototype, it may be of interest to point out the enormous advantages which these standards bring, by comparing the old and the new routes. This is done in Table I ; the comparison of access points and accident rates is especially striking.

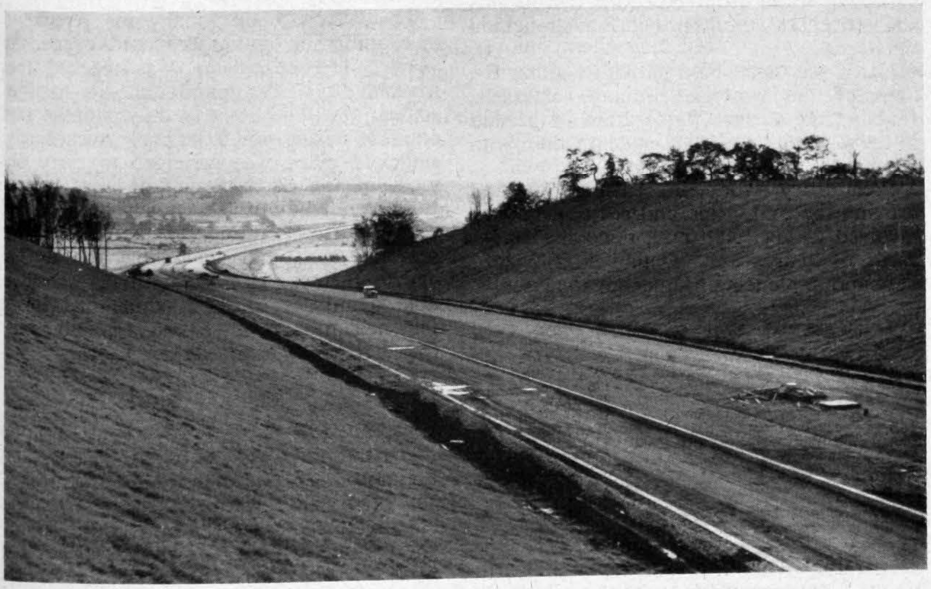
Table I—*Comparison Between the New By-Pass and the Existing Route*

	North-South Motorway (Preston by-pass)	Existing route
Minimum width	112ft	31ft
Minimum radius	3015ft	50ft
Maximum gradient	1 : 25	1 : 14
30 m.p.h. speed limit	Nil	97 per cent
Length	(i) Excluding north link to A.6 7·26 miles	6·76 miles
	(ii) Including north link to A.6 8·26 miles	—
Access points	2	1898
Estimated car travelling time	8 to 12 minutes	17 to 90 minutes
Accident rate per million vehicle miles	0·40 (estimated)	5·80 (actual)

Casualties between April, 1946, and April, 1956, on the existing route proposed to be by-passed totalled 1170.

Carriageway Design

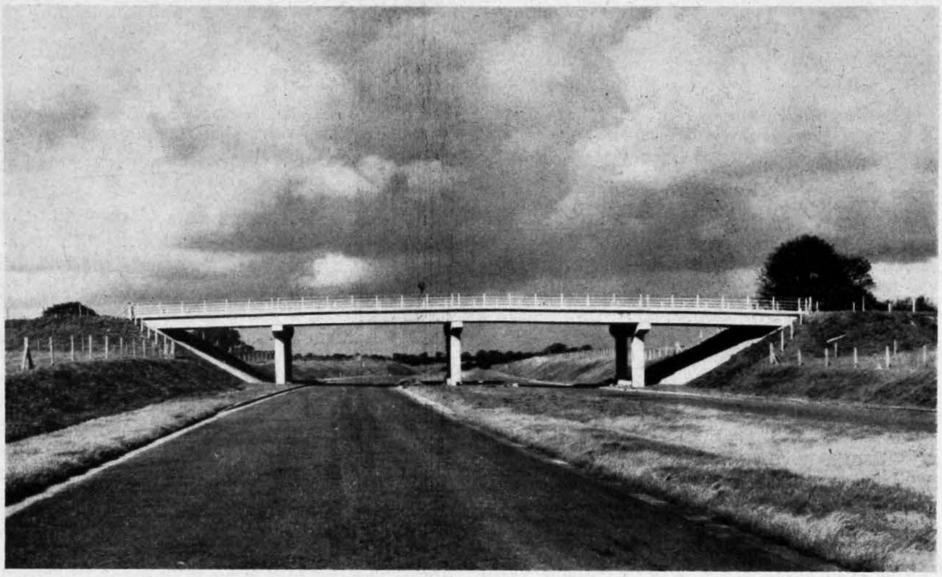
Design was based on the results of extensive soil surveys. Borings were carried out by the county highways laboratory. The soils encountered were predominantly clays, with wet sand and silt veins occurring at the deep



The motorway, looking south from the north escarpment of the Ribble Valley

cuttings. Percussion rigs, equipped with a power-operated winch and capable of drilling 5in and 6in diameter bores to a depth of 100ft, were used for boring. Boreholes were made at approximately 200 yard intervals in both cut and fill areas. Normally, four additional boreholes were taken at each bridge site. Undisturbed soil samples were obtained from each borehole in 4in diameter tubes 1ft 6in long.

All soil tests were carried out at the county highways laboratory, which carries a full range of soil testing equipment. The *in situ* wet and dry density and shear strength of the soil were obtained from the undisturbed samples. The unconfined compression test was carried out on clays to obtain the shear strength and the triaxial test was used for sands and sandy clays. Other tests included classification of the soil, determination of liquid and plastic limits and particle size analysis. From all the soil test data the depth of construction of the carriageways and the design of safe slopes for cut and fill areas were determined. The site investigation involved a total of 199 boreholes with a total depth bored of 5150ft.



Broughton Hall bridge carries a Class III road over the motorway, the spans being 36ft 6in, 49ft, 49ft and 36ft 6in. The width of the bridge is 34ft, piers and abutments are on concrete piles and the deck is of precast prestressed concrete beams

The carriageways are of flexible construction, designed to the 20,000 lb wheel load curve to the Ministry's specifications. As mentioned above, the soils along the route are chiefly clays, and the depth of construction depended on the C.B.R. values of the subgrade, determined during construction. The thickness of the sub-base was varied to obtain the required construction depth. The exceptionally heavy loads and weak clays necessitated in places a deeper construction than normal. For the greater part of the sub-base, a local waste product, burnt colliery shale, was used. Its depth varied from 12in to 36in.

This sub-base was covered by a 9in thickness of premixed waterbound macadam, followed by a 2½in tarmacadam base course, with a ¾in cold asphalt surface in which were embedded precoated granite chippings. The final course, after settlement of the road has taken place, will be a rolled asphalt wearing coat. The whole of this construction has been effected mechanically, and it utilises local materials. The premixed waterbound macadam, developed by the county council, is considered to have proved satisfactory.

The hard shoulders consist of a minimum compacted thickness of 4½in of gravel, topped with a 4¾in compacted thickness of a mixture of stone, sand and loam; the shoulders are sown with grass and merge with the verges.

Earthworks and Drainage

Surface water from the carriageways and hard shoulders is collected by cast *in situ* concrete drainage channels sited along the outer edges of the "hard shoulder," or on super-elevated sections of the by-pass in the central island and the outer edge of the hard shoulder on the low side. From these channels water enters the general water drainage system running along the road and discharges into existing water courses at selected points.

Where the road is in a deep cutting, the concrete drainage channels are replaced by French drains, which also collect the face drainage of the slopes. In certain very deep cuttings, such as the north escarpment of the River Ribble, the French drains in the side verges have been increased in dimension to act as shoulder drains at the base of the banks, and will form a support as well as collecting water from the deep face drains and herringbone drains provided to strengthen the slopes.

Catch pits have been provided along the lines of the concrete drainage channels, enabling the surface water drain to be laid in the verges at a shallower depth than with the normal type of gulley.

Preliminary work in setting out and proving the centre line and clearing the site involved felling 1500 trees, removing 10,000 yards of hedges and erecting 30,000 yards of temporary fencing. Other equally essential preparatory work involved the "pre-earthworks" drainage works needed to deal with the many ditches, streams and other water-courses crossing the by-pass, many of which were converted to pipe or box culverts ranging from 9in diameter earthenware pipes to 9ft by 9ft box culverts. In addition, long lengths of storm water drains, which will form part of the main by-pass drainage system, have been constructed.

Table II—*Constructional Quantities*

Excavation	3,400,000 tons
Imported filling	668,000 tons
Ashes	176,000 tons
Red shale underbed	288,000 tons
Premixed waterbound macadam	120,000 tons
Tarmacadam base coat	31,000 tons
Cold asphalt surfacing	12,000 tons
Drains and sewers	55,000 yards
Concrete	35,000 cubic yards
Reinforcing steel	950 tons
Structural steel	2,900 tons
High tensile prestressing wire	220 miles
Piling in bridge foundations	21,000 lineal feet

The construction of the by-pass also required the alteration or diversion of seventy-eight statutory undertakers' services, including several important trunk mains.

Earthworks for the construction of the by-pass have been heavy, as is shown by the figure in Table II (which also lists quantities for the bridgeworks). Excavation was carried out to the extent of 2,250,000 cubic yards. The maximum depth of cutting was 62ft and the maximum height of embankment 56ft.

To deal with the heavy earth-moving programme, the contractor assembled at the start, in June, 1956, a fleet of heavy plant which included tractors, scrapers, large capacity excavators, and rear dump trucks, but the heavy rains of the autumn of 1956 made it virtually impossible to work the sandy clay sub-soil and so the heavy earth-moving was postponed until the following spring (1957) and the contractor was granted a five-months' extension of contract.

On reassembling the heavy plant, there was a welcome respite from the rains, and over the ensuing fine period of some twelve weeks intensive work enabled about 50 per cent of the excavations to be completed. Then the previous year's experience repeated itself and, until a brief fine spell in the spring of 1958, ground conditions made it possible for earth moving to proceed only at a fraction of the desired rate. Nevertheless, the contractor used every means available to overcome the physical difficulties, with the result that the works have been completed within the revised contract period of two years five months.

In order, however, for this to be accomplished, it was found necessary to authorise the running to tip of large quantities of excavation of which, had weather conditions permitted, much could have been used for embankment construction, and this tipped material had to be replaced by imported material. The problems arising from the incessant rains were many and varied, one instance being the deep cutting through the south escarpment of the Ribble, where it was found necessary to redesign a portion of the eastern slope. It was also found necessary to remove an unsuspected peat bog in the Ribble Valley.

The contractor's original plans were based on examination of weather records over eighty years. The conclusion was reached that March, April, May and June—a total of sixteen weeks—were the only months that could be relied upon to be fine. Accordingly, sufficient plant was arranged to carry out most of the earth-moving in that period. But, as already noted, much of the spoil removed from cuttings at the start of the season was found unsuitable for use in embankments. In some cuttings considerable quantities of lump stone had to be punched into the silt to make a stable base for carriageway construction.

Bridgeworks

Twenty-two bridges are built over or under the motorway, as follows: two carry the motorway over both a river and a road; six carry the motorway over roads and streams; six carry roads over the motorway; one carries the motorway over a railway; one carries a railway over the motorway; and six carry "occupation" roads and footpaths over the motorway.

The Preston by-pass motorway at the junction with the Preston-Whalley road. At this point the motorway crosses the River Ribble and sweeps away to the northward

The cost of the bridgeworks is about a third of the total.

The main bridges are designed for Ministry of Transport standard loading, including the abnormal indivisible load—180 tons on four axles—for the motorway bridges.

The two principal bridges are (*a*) at Samlesbury, over the River Ribble and trunk road A.59—a three-span continuous steel girder bridge of spans 120ft, 180ft and 120ft, giving a total length of 420ft between abutments which, together with the piers, are stone faced, and (*b*) at Higher Walton over the River Darwen and county road A.675, a multi-span continuous steel girder bridge carried on concrete trestles with four main spans of 97ft 6in each and two end spans of 42ft 9in, an overall length of 474ft.

The remaining bridges are of single, three and four spans, twelve of them having prestressed concrete decks and three having decks of steel girder construction. Five, comprising two footbridges and three large culverts, are of reinforced concrete. In five cases ground conditions necessitated piled foundations.

A statutory headroom of 16ft 6in has to be provided at all bridges so a headroom of 17ft has been allowed, the additional 6in being for any slight settlement of the bridge during and after construction and for the re-surfacing of the roads under the bridges.

For overbridges four-span structures have usually been adopted as this gives a minimum depth of construction and is therefore generally more economical, particularly in those cases where the road being taken over the motorway has to be raised on embankment to make the crossing. There were, however, certain conditions under which it was considered advisable to adopt alternatives to the four-span. For example, where the motorway is on a curve a pier in the central reservation may interfere with the sight lines of the traffic, and in these cases a single span has been adopted. In another case, at Pope Lane, the motorway is in deep cutting and here a three-span bridge has been built.

For the underbridges, single spans have normally been used. The occupation bridges, all of which are over the motorway, are of four-span construction.

In both prestressed and steel construction, where a reinforced concrete slab is supported by beams, composite construction was allowed for in the design, and interaction between the slab and beam was ensured by shear connectors. In most of the prestressed concrete decks the beams were of such a size and weight that they could be produced in a factory and then transported to and erected on the site. In all cases of prestressed beam construction, the deck, after erection of the beams and the casting of the *in situ* concrete, was transversely stressed.

At Cuerdale Road, where there is a large angle of skew (44 deg.), the bridge is a continuous steel girder over four spans, whilst at Longridge Road provision for large water mains serving Preston required deep girders and, as the motorway is on a curve, a single-span with steel girders was built. The bridge carrying the railway over the motorway at Ribbleton is a through girder type of single span.

The footbridges are three-pin arches, with ribs pre-cast in reinforced concrete, whilst the bridges over the smaller streams are reinforced box culverts.

Design and supervision of construction of the entire Preston by-pass—with the exception of one bridge—has been in the hands of the county surveyor and bridgemaster of Lancashire, Mr. James Drake, M.I.C.E., and his engineering staff. Close co-operation has been maintained with the chief engineer, Mr. J. F. Baker, M.I.C.E., and the north-western divisional road engineer, Mr. V. H. Haynes, A.M.I.C.E., of the Ministry of Transport and Civil Aviation. The bridge mentioned above is the Preston–Longridge railway bridge, which was the responsibility of the chief civil engineer of the London Midland Region of British Railways, Mr. J. Taylor Thompson, M.I.C.E.

The main contractor for the motorway was Tarmac (Civil Engineering), Ltd., the tender price being £2,432,360. The sub-contractor for bridgeworks in this tender was Leonard Fairclough, Ltd., which firm also obtained the contract for the Preston–Longridge bridge. The two large bridges were let separately, the contractors and contract sums being respectively; for Samlesbury bridge, the Cleveland Bridge and Engineering Company, Ltd. (£334,431), and for Higher Walton bridge, Dorman Long (Bridge and Engineering), Ltd. (£193,690). Construction of the main works started in June, 1956, and the total estimated cost, including land acquisition, alteration of services, design and resident staff, has been quoted at £3,147,000.