History of Electrical Engineering on Merseyside

HISTORY OF ELECTRICAL ENGINEERING
ON MERSEYSIDE

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Jubilee Publication of
Mersey & North Wales Centre of the IEE

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FOREWORD

It was Sydney Towill, a past Chairman of the Mersey & North Wales Centre of the IEE, who had the idea for this book. He felt, and the Centre Committee agreed, that the Jubilee of the Centre, which came in 1973 should be marked by a publication giving the history not only of the Centre, but of the growth of Engineering and the background to that growth in the area of Merseyside and North Wales.

We were fortunate in having within our ranks an author to tackle such a project. As the chapters reached us from Mr. Parson's pen we realised more and more that not only had he made an interesting record, but he had caught the underlying romance of the events of the past century. It makes a fascinating story.

A publication like this would not have been possible without those firms who have contributed the advertisements which in themselves form a complement to the history in the text. I would like to acknowledge their generous co-operation. I would also like to record our thanks first of all to Mr. Parsons, then to Mr. S. Towill, Mr. A. V. Milton and Mr. B. Nield who worked with me on the publication committee together with Mr. H. Currie on whose shoulders have fallen the brunt of all the detailed publication arrangements.

J. C. Ireland

Chairman, Mersey & North Wales Centre I.E.E. 1973/74

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Comparative figures relating to the supply of electricity have been extracted from the 'Handbook of Electricity: Supply Statistics (1972)'.

May, 1973 S. A. J. PARSONS

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CHAPTER 1

HISTORICAL BACKGROUND

The march of events, the scientific revolution, the speed and pattern of technological change have all contributed to the tempo and challenge of modern life. The industrial society in which we live is the result of the work of many classes of individuals, of whom electrical engineers form a vital sector. The situation which exists today is possible, and has been largely determined, through the utilization of electrical energy. It has been clearly demonstrated that the nation's activities can be halted quickly if the supply of electricity is seriously curtailed. Therefore, the Golden Jubilee of the formation of the Mersey & North Wales Centre of the Institution of Electrical Engineers in 1973, which followed closely on the Centenary of the founding of the Institution itself, celebrated in 1971, provides an opportunity to look back and record some of the important events of the past.

THE CONURBATION KNOWN AS MERSEYSIDE

A branch or centre of a professional institution is influenced to a high degree by the character of its environment, that is through the area in which it was founded and developed and in which its activities are undertaken. This is certainly true of the Mersey & North Wales centre of the Institution of Electrical Engineers. The area served by the Centre consists of south-west Lancashire, west Cheshire, a small part of Shropshire (bounded by straight lines between Southport, Wigan, Warrington, and in the direction of Wrexham, up to the County boundary), Flintshire, Denbighshire, Caernarvonshire, Merionethshire, Montgomeryshire, Anglesey and the Isle of Man, as shown in the frontispiece. It includes the conurbation known as Merseyside which is unique, and forms a compact area in the North-West Region. In 1973, it consisted of a number of local authority areas situated on the banks of the River Mersey. They include the county boroughs of Bootle and Liverpool, the municipal borough of Crosby, and the urban districts of Huyton-with-Roby, Litherland, Formby, Kirkby, Prescot and Widnes on the north bank; the county boroughs of Birkenhead and Wallasey, the municipal boroughs of Bebington and Ellesmere Port, and the urban districts of Hoylake, Neston, Wirral and Runcorn (which has been designated a new town) on the south bank. Important centres adjacent to Merseyside are the City of Chester, St. Helens, noted for its glass-making, and Warrington. North Wales is discussed later in this chapter.

The growth and development of Merseyside have resulted from its association with the sea. This factor has been the primary source of its wealth and material prosperity until the recent past, and commenced with the introduction of the slave trade and the growth of the cotton trade. These activities naturally attracted commercial interests that resulted in the provision of banking, insurance and other essential services. In due course a variety of industries was drawn to the area. The river that flows over the Mersey tunnels, and on which the ferry boats shuttle from shore to shore, continues to provide one of the two stabilising forces – the other is manufacturing industry – upon which the future of Merseyside depends.

NORTH WALES – THE PATTERN OF DEVELOPMENT

The northern half of the principality included in the boundaries of the Mersey & North Wales Centre, benefited from the needs of the Second World War, which provided the initial impetus that led to the growth of manufacturing industry in the area. North Wales was affected by the industrial revolution of the 18th century in common with the remainder of the United Kingdom.[1] The Welsh woollen industry developed. Canals were built. Thomas Telford built the Pont Cysyllte aqueduct across the Dee Valley to carry the Ellesmere Canal. It took eight years to construct, and was completed in 1803. The reconstruction of the London to Holyhead Road was undertaken

in the first half of the 19th century, with Thomas Telford as engineer, primarily to facilitate the passage of the Irish mails. The Welsh section of the road necessitated the building of two suspension bridges, one at Conway, over the River Conway, and the other spanned the Menai Straits near Bangor. The whole of the construction was completed by the early 1830s. The Holyhead road retained its importance as a coaching highway until the introduction of railways. The Chester & Holyhead Railway opened in 1849, and later became part of the LNWR network, linking London and Holyhead.

Robert Stephenson built the Britannia Bridge across the Menai Straits, carrying the Holyhead Railway, which was of tubular construction. Work commenced in 1846, and the bridge was completed four years later. A similar type of bridge was constructed by Stephenson at Conway. The Britannia Bridge was severely damaged by fire in 1970, and was out of use for some 20 months. It was then reconstructed with steel spandrel braced arches and reopened for traffic early in 1972. It is proposed to remove the original wrought iron tubes. Eventually it is intended to construct a 3-lane road above the railway.

The development of the iron industry was influenced by John Wilkinson. Copper was mined in Caernarvonshire and Anglesey. Gold was discovered in Merionethshire. Lead was found and coal mining undertaken in Flintshire and Denbighshire. Slate quarrying in Caernarvonshire and Merionethshire was important. The transport of slates led to the growth of ports at Caernarvon; Port Penrhyn, near Bangor; Port Dinorwic, near Llanberis; and Portmadoc, serving the slate quarries at Blaenau Ffestiniog. These ports were active until the introduction of the steamship, and the reduced demand for slates. Coal was mined in Denbighshire and Flintshire. Collieries in the Wrexham area are now the only ones of any significance. The small iron and steel industry is found in the same counties. Chemicals are found at Cefn, near Ruabon, in Flintshire, at Sandycroft, and Connah's Quay. Paper mills were formerly found in Denbighshire, but they are now confined to Holywell, Flint and Oakenhurst in Flintshire, the county in which textiles are manufactured.

The development which followed after the Second World War resulted in the plants used for the production of aircraft and munitions being converted for the manufacture of domestic appliances, electronic equipment, electrical components, optical glass, plastics and other products. The Development Corporation for Wales encouraged the setting up of these new and widely diversified industries in North Wales. Aluminium smelting at Holyhead, and rolling mills at Dolgarrog, in Caernarvonshire, provide the principality with a share in this important industry.

THE PORT OF LIVERPOOL

Liverpool's first wet dock was constructed on the site of the former Custom House in Canning Place, and opened for service in 1715. Some years later, the first dry dock was constructed. These undertakings formed the nucleus of the vast docks complex which extends some seven miles on the Liverpool side, and about four miles on the Birkenhead side of the river. During the period from the building of the first dock until 1927, when the Gladstone system of docks was carried out, there had been a continuous expansion of port facilities. However, in the late 1960s it became obvious that new work would have to be undertaken to cater for the larger ships coming into service, and the scheme known as the Seaforth project was planned and authorised. This site of 530 acres added another mile and a half of quays and provided for ten deep water berths. The former Gladstone Dock was converted into a container terminal on the assumption that the work would eventually be handled at the Seaforth terminal.

Recent developments have provided facilities for the handling of bulk cargoes including iron ore, grain, sugar and petroleum, necessitating the provision of modern discharging equipment. The Port of Liverpool is one of the country's leading oil ports. The Tranmere oil terminal, put into operation in 1964, was constructed jointly by the Shell Refining Co. and the former Mersey Docks & Harbour Board. The crude oil which is discharged is refined at Stanlow Refinery. The original site of 50 acres has been extended so that it now covers nearly 2000 acres.

Until 1857, the Town Council was responsible for the Port of Liverpool through a Dock Committee. In 1853, a Royal Commission recommended that a new body should be established to control the dock system and, as a result, the Mersey Docks & Harbour Board was set up and took over full responsibility. Unfortunately, a financial crisis necessitated a reconstruction of the controlling authority, and, in 1971, the work of the Board was taken over by the Mersey Docks & Harbour Co.

A second docks system is located at Garston, a few miles upstream from the main dock area. It is administered by the British Transport Docks Board. The system consists of three docks covering an area of some 29 acres, modernised to cater for container traffic. Further upstream will be found the Runcorn Docks owned by the Manchester Ship Canal Co. These docks can handle vessels up to 2000 tons cargo capacity. A container berth is available.

TRANSPORT AND COMMUNICATION

The swift running tidal river that became the artery around which Merseyside grew posed many problems to all those people who, for a multitude of reasons, had to move about or pass through the area. Traffic problems are common to all cities, but the River Mersey presented an unusual obstruction not encountered elsewhere. The river is three-fifths of a mile wide at the pier head, and rises and falls about 30 feet with the tide.

An essential feature in the everyday activities of a great port is the provision of a system of communication which will ensure easy access for vehicles serving the docks and the locality as a whole. For a long period, indeed for many centuries, the river itself provided the only means of transport between the land on its banks, and ferry boats are still a feature of the Merseyside scene. As the business of the port grew and trade expanded, the need for improved methods of transport in the area became evident.

CANALS

Canals were constructed in the latter half of the 18th century, following the success of the Bridgewater Canal, connecting Manchester and Worsley, designed and constructed by James Brindley. Many canals were successful commercially and provided a new method of transport for raw materials, coal, foodstuffs, and goods of all kinds. The system of canals was completed by 1830, and those in the north west included the Mersey and Irwell Navigation, Leeds and Liverpool, Ellesmere and Chester, and the Trent and Mersey. The Ellesmere and Chester Canal includes the Pont Cysyllte aqueduct across the Dee Valley, built by Thomas Telford. In North Wales, canals were constructed in Denbighshire and Montgomeryshire. The apex was reached in 1894, when the Manchester Ship Canal was opened. This permitted ocean-going ships entering the River Mersey to continue some 30 miles inland to reach the heart of Manchester. Although the canal system as a whole declined, mainly as a result of the introduction of railways, British Waterways continue to operate certain services using barges with a carrying capacity of up to 400 tons.

MODERN ROADS AND TUNNELS

In 1915, when John A. Brodie, Liverpool's city engineer, addressed the Liverpool Engineering Society on communication, he stated that Queens Drive was just being completed between Sefton Park and Walton. He believed in the need for wide roads and instanced Princes Road, constructed in 1880, as an excellent example. It was 126 ft wide between boundary walls and 190 ft between buildings. The speaker suggested that 'this road may today be taken as an example of thoroughly warranted foresight'.[2]

The modern road system on Merseyside emerged in the 1930s when the first Mersey road tunnel was built and the East Lancashire Road constructed. Liverpool's roads had improved from the beginning of the century. At the commencement of the Second World War, the system of main roads and dual carriageways was considered to be adequate for the conditions then prevailing. It was not until the cessation of hostilities that further projects were undertaken. Before the first tunnel was built, all river crossings were undertaken using the ferries, except at the Runcorn-Widnes area, which was served by a transporter bridge, erected early in the century. The amount of traffic this could handle was very limited. Various schemes for a road bridge were suggested, but it was not until 1965 that a start was made on a new bridge. When the Runcorn-Widnes road bridge was completed and opened in 1961, it became the largest single span in Europe. The transporter bridge was then demolished. The development of motorways in the 1960s and early 1970s saw the construction of the M6, with junctions at Haydock and Warrington; the M62, the trans-Pennine motorway, linking Merseyside with Humberside; and the M56 in Cheshire.

Merseyside is famous for its rail and road tunnels. The first tunnel crossing the river was built for the Mersey Railway, and was opened in 1886. The first road tunnel connecting Liverpool and Birkenhead was commenced in 1925 and officially opened by HM King George V in July 1934, when he was accompanied by Queen Mary. It is the largest subaqueous tunnel in the world, and is 2·13 miles long.

Within 30 years, it became evident that a second crossing would become necessary. Eventually, it was decided to construct a second tunnel. The first of twin 2-lane tubes was commenced in 1967 and opened by HM Queen Elizabeth II in June 1971. Both the entrances and exits are located away from areas with dense traffic problems, and will be eventually linked directly to the motorway complex. The original tunnel incorporates cast iron segments to form the lining. In the second set of tunnels, the accurate machine-boring operation, using the 350 ton mole, permitted precast reinforced concrete segments to be used, which resulted in a considerable reduction in cost.[3]

RAILWAYS

The opening of the Liverpool & Manchester Railway in 1830 introduced a new and vital link in the transport system in the north west. Its development permitted regular and fast services of goods traffic between Merseyside, its hinterland, and beyond. In 1839, the Birmingham-Liverpool and London-Birmingham railways made possible the through journey from Liverpool to London. Various amalgamations brought the London & North-Western Railway into existence in 1846, and this line connected Birkenhead with London. Later it became part of the Great Western Railway. Trains from Liverpool to London were originally routed through Warrington. To shorten the journey, it was decided to build a railway bridge over the River Mersey at Runcorn. This bridge was opened in 1869. At that time, it constituted the longest bridge of its kind constructed in England. It spans both the Mersey and the Manchester Ship Canal, and stands about 75 ft above high-water mark.

Liverpool, Crosby & Southport Railway

The Liverpool, Crosby and Southport Railway (LC&S Rly) was sanctioned by an Act of Parliament in 1847, and completed by October 1850. The original terminus at Southport was in Eastbank Street. It was transferred to Chapel Street in 1851. Omnibus services were provided on behalf of the railway between Waterloo and Lime Street Station, and between the old village of Southport (Churchtown or North Meols), two miles distant. The line was absorbed by the Lancashire & Yorkshire Railway in 1855. In 1904, the Southport line was electrified, the work having commenced the previous year, over a distance of 18½ miles, utilizing the 3rd-rail system, and operating at 600 V d.c. New rolling stock was provided in 1938.

Mersey Tunnel Railway

The Mersey Railway Co. was the first railway in this country to change over to electric working. In addition, it was the first to operate its trains exclusively on the multiple-unit system of control. The latter was an American invention, which incorporated a master controller fitted in each trailer car, working on a low-voltage supplied by batteries. This system eliminated the need for main cables to be fitted in the trains. Each controller could be used independently to control the power output of the electric motors of the cars making up the train. Incidentally, the original rolling stock remained in service until 1956.

In a paper entitled 'Notes on the Mersey Railway' by Joshua Shaw, M.Inst.E., M.I.Mech.E., M.I.E.E., read at a meeting of the Liverpool Engineering Society in December 1915,[4] the lecturer recalled that Parliamentary powers were obtained in 1871 to construct a tunnel with a double line of rails under the River Mersey. The railway was opened for traffic in February 1886, when the section from James Street, Liverpool, to Green Lane, Birkenhead, was completed. The tunnelling was successfully undertaken using a Beaumont boring machine. Further extensions were opened in 1888 and 1891. In the following year, the extension to the Central Station, Liverpool was opened. Steam locomotives were used in the first instance, but the ventilation was poor and the service did not prove attractive to passengers. As a result, it was decided to electrify the line. The electrically operated system was put into service in May 1903. The change proved beneficial to progress and the financial position greatly improved.

The original railway was four miles, 62 chains in length. The main tunnel was 26 ft wide and stood 19 ft high above rail level. The power plant employed at the North Shore Station, Birkenhead, consisted of three vertical cross compound engines driving a.c. generators, each of 1250 kW capacity. A new mixed pressure turbine set was put into service in 1913, designed for an output of 800 kW. The lighting was taken from an independent supply. Each motor car was fitted with four motors of 100 hp, working at 550 – 650 V, and the trains were electropneumatically controlled. A 5-car train employed eight 100 hp motors and weighed 132 tons. The maximum current required was 1600 A, or 900 kW.

There were physical connexions with the former London and North-Western Railway and the Great Western Joint Railways at Rock Ferry Station, and with the Wirral Railway at Birkenhead Park Station. These were steam railways; so it was necessary for passengers to change at the stations mentioned. The Wirral section was electrified in 1938. Ten years later, the Mersey Railway became the Mersey Section of the London Midland Region of British Railways (now British Rail). The latest development is the extension put in hand in 1971 for the first phase of Liverpool's new underground railway, an extension of the Mersey Railway. The work which is estimated to cost more than £12 million, is planned to be completed in 1975. The work provides for a new single line underground railway, approximately two miles long, from James Street to Moorfields (Exchange), Lime Street and Central, returning to James Street.

Liverpool Overhead Railway

Schemes for an overhead railway in Liverpool were proposed from 1852 onwards. Finally, in 1888, Sir William Forwood and others promoted a company, and the structure was designed by Sir Douglas Fox and J. H. Greathead. When it was completed, the overhead railway not only provided an important means of transport, but gave visitors a fascinating panoramic view of the dock system on the River Mersey.

In his presidential address[5] to the Liverpool Engineering Society in 1898, J. A. Brodie said it was well known that the public are quick to take advantage of improved travelling facilities, and he compared the number of passengers carried along the line of docks on omnibuses prior to the completion of the overhead railway, numbering 2 250 000 with those carried by the overhead railway in 1898, which reached nearly 9 000 000.

The history of the Liverpool Overhead Railway is recorded in a paper read to the Liverpool Engineering Society jointly with the Mersey & North Wales Centre of the IEE, by H. Maxwell Rostron, M.I.Mech.E., M.I.E.E., who was Engineer and Manager for 13 years, in 1952.[6] It was the first electrically operated elevated railway in the world, and the only one in this country. The standard gauge double track, extended from Seaforth in the north to Dingle in the south, a distance of 6 miles, 40 chains. The first section, from Alexandra to Herculaneum, was opened in March 1893, and completed to Seaforth Sands in 1894, and to Dingle, through a halfmile-long tunnel, in 1896. 9 years later a short connection was made to link the railway with the main lines of the Lancashire & Yorkshire Railway.

The elevated structure consisted mainly of wrought iron girders, at 22 ft centres, with a 50 ft span, constructed 16 ft above the roadway, and supported on steel columns (Figs. 1 and 2). The system included four hydraulically operated opening bridges and 17 stations. In 1952, 19 3-car trains were employed with a peak hour service of 3-5 min, and a running time for the overall journey of 28 min, including stops. The average speed of the train was 14 mile/h. At that time, some 12 million passengers were carried annually.

When the overhead railway was built, electrical energy was supplied from the company's generating station at Bramley Moore Dock, but, in 1927, rather than undertake the replacement of worn out plant, a supply was obtained from Liverpool Corporation. The railway operated through a 3rd-rail system at 500 V d.c. A contact rail was used to convey current to the four 75 hp motors used on each train, and, at the same time, the d.c. was converted to a.c. at 600 V, 50 Hz, for the signalling system, which was automatically operated throughout the life of the railway.

The original trains consisted of two 45 ft motor coaches accommodating 16 first-class and 40 third-class passengers. Fig. 3 shows the interior of an original third-class coach. Each coach had two 60 hp motors, with armatures mounted directly to the driving axles, with series parallel control. However, following the competition which resulted from Liverpool Corporation's electrified tramway system, trains were fitted with four 100 hp totally enclosed motors, and the journey time was reduced from 32 to 28 min. Subsequently, the motors were changed again, and four 75 hp self-ventilated series wound 4-pole, interpole machines were fitted. They were axle-hung, and drove through spur gearing having a ratio of 17:70.

The company installed the first escalator (the 'Reno' elevator of Otis manufacture, Fig. 4) ever employed for railway purposes for use by the public, which was installed in 1901, but it was taken out of service when the new station at Seaforth Sands was built in 1906.

The undertaking was severely damaged during the Second World War, but every effort was made by the company, assisted by the Ministry of Transport, to restore the railway and provide an efficient service, at the conclusion of hostilities. In the 1950s, difficulties in the form of increasing costs, and the need of extensive reconstruction, resulted in closure. The final journeys were made by trains running on the 30th December 1956, and the structure was then demolished.

Railway electrification

The construction of the Liverpool Overhead Railway, the electrification of the Mersey Railway, and the Liverpool Southport Railway, heralded the introduction of railway electrification on a much wider scale. These were all 3rd rail d.c.-schemes, but some overhead high-voltage projects, either a.c. or d.c., were introduced before the First World War. One of these was the 6·6 kV a.c. system adopted on the Lancaster–Morcambe–Heysham line. In 1929 the report of the Weir Committee recommended that all the country's main lines should be electrified, using a 1500 V d.c. system. However, little progress was made on main lines, but the Wirral and the extensive Southern Railway network proceeded as 3rd-rail schemes. The Second World War delayed further progress.

In 1955 a comparative study was made of the 1500 V d.c., and the 25 kV, 50 Hz, systems. The decision was made that future developments should be based on the latter system, and the Euston–Manchester– Liverpool main lines were selected as a pilot scheme for electrification. Planning and survey work commenced in 1957, which resulted in a new era in railway travel as the various sections were completed progressively until the full service between London and Liverpool and Manchester was opened in 1966. The new inter-city service with its greatly improved timetable produced a spectacular increase in passenger traffic. The £160 million project included complete resignalling, improvements to the track, raising bridges to provide clearance, and the remodelling or reconstruction of a large number of stations and several junctions. New rolling stock and electrical locomotives were designed and constructed. The 3300 hp Bo-Bo locomotives, weighing 80 tons, and capable of speeds up to 100 mile/h, incorporated rectifiers to convert the 25 kV single-phase supply to d.c. for the traction motors.

The engineering work included the strengthening of approximately 1380 single-track miles to permit train speeds up to 100 mile/h. Some 330 miles of track were laid with continuous welded rail, which resulted in a much smoother and quieter journey for passengers. It also permitted sustained high speeds over long distances. In addition, the continuous-welded rail resulted in a reduction of maintenance charges. The cadmium–copper overhead contact wire was supported over a distance of 1750 miles by 22 000 structures fabricated from 40 000 tons of steel. The manually operated signalling system was replaced by multi colour light signalling, in association with an electronically operated automatic warning system for locomotive drivers. Views showing the London Midland Region rail electrification in progress are shown in Figs, 5, 6 and 7. They comprise various stages of construction undertaken by British Insulated Callender's Cables Ltd., the contractor. Fig. 8 shows an electrically hauled passenger train emerging from Shugborough tunnel, following the completion of the Euston–Crewe section of the line. The constructional work shows a 2-track portal carrying overlap spans, erected by BICC.

TRAMWAYS

Tramways were a popular form of transport in a number of areas on Merseyside for many years. In Liverpool, the tramway system was a prominent feature for some 95 years. Its early history and subsequent

development were discussed in papers presented to the Liverpool Engineering Society.[7] Records are also available in the archives of the Merseyside Passenger Transport Executive.[8]

The modern form of street tramway line and tramway vehicle were introduced into this country from America in 1860. G. F. Train, from Boston, Mass., constructed and equipped the first lines in the United Kingdom at Birkenhead, between Woodside Ferry and Birkenhead Park.[9] He employed 48-seater, double-decked, horse-drawn trams, built in Birkenhead by Robert Main. Two single-decker trams were also constructed. London and Liverpool followed this lead shortly afterwards. Further lines were constructed in Birkenhead and acquired by the Corporation in 1889, who leased them to private operators. The tramways were electrified in the early 1900s.

The rails of the first tramways protruded above the road surface and interfered with other vehicular traffic, which resulted in their being removed after a short time. There were no further important developments for some years. However, in 1868, the Liverpool Street Tramways Co. obtained an Act of Parliament authorizing the construction of the Inner Circle and Walton and Dingle routes of street tramways, covering about 9·5 miles of track. Further powers were obtained two years later. In the course of time, the routes became dangerous, because they were badly maintained. In 1877, certain routes were relaid by Liverpool Corporation by arrangement with the company which bore the cost of the work done. The latter was directed by G. F. Deacon, the Liverpool Borough and Water Engineer. Born at Bridgewater in 1843, he attended Glasgow University, and then obtained practical experience at the works of Robert Napier & Son. At the age of 22, he commenced practice as an engineer in Liverpool. Following a voyage with Lord Kelvin in an attempt to lay an Atlantic cable, he returned to Liverpool and continued his practice until 1871, when he was appointed to his post with the local authority. In 1877, he became President of the Liverpool Polytechnic Society, and was elected a member of the Liverpool Engineering Society. He worked on the Lake Vyrnwy scheme from 1879 to 1892. He died in 1909.[10]

When the tramways were reconstructed, wooden sleepers were used. Later, cast-iron sleepers were tried, but were found to have a shorter life and to be noisier than the wooden sleepers. In 1895, horses were still in use on 80% of the tramways then operating. Steam engines were introduced that used an ordinary locomotive type boiler incorporating a condenser, but they were not generally favoured. The cable system was sometimes employed, but not in Liverpool. The city's extension of boundaries, coupled with the urgent need for improved services led the Corporation in 1897 to acquire the entire system of tramways and omnibuses from the Liverpool Tramways & Omnibus Co. for £567,375. The system consisted of 75 miles of single-track and 267 vehicles. The standard gauge 4-wheel trams were 32 ft long, and weighed 12½ tons. The annual mileage exceeded 6 million, and more than 34 million passengers were carried. Gross receipts amounted to some £289 000. In 1898, a start was made on relaying the track for the adoption of electric traction. A single overhead conductor supplied current at 500 V, with rail return. The power supply was obtained from the generating station in Paradise Street from plant distinct from that for the lighting supply. The first electrified route was opened on the 16th November 1898. The cars were single-deckers with 20 seats. They could tow a trailer, which provided seats for another 18 persons.

As a result of the success of the initial undertaking, the City Council promoted a bill for the conversion and extension of the whole system. The Act which followed gave the Council powers to construct 114 miles of tramways, and the work of conversion commenced in January 1899. In the first year, 30 miles of route were converted, and during the first six months of 1900, a further 27 miles of track were electrified. The double-decker standard car used was built on a single truck and measured 27 ft overall. It weighed 8 tons, and carried 56 passengers. Running costs were slightly less than one Board of Trade unit of electricity per mile. Each car was driven by two 25 hp electric motors. At the time, 220 cars were being built, and orders had been placed for a further 230.

Considerable trouble had been taken to evolve the most efficient tramcar. Some of those intended for the Dingle route were imported from Germany and the USA. The idea of the double-decker tramcar emanated from Glasgow, and various models were obtained from manufacturers including the British Thompson-Houston Co., the Brush Electrical Co., Westinghouse Electrical Co., and Dick, Keir & Co. The good points of all the vehicles purchased and other known

makes were incorporated in the design of Liverpool's tramcars. In 1903, Liverpool Corporation commenced building their own vehicles at the Lambeth Road Works. Between 1908 and 1913, first-class travel was introduced on various routes utilizing the lower deck for this purpose. Fig. 9 shows one of the tramcars incorporating first-class travel, constructed in 1908. In 1912, two new types of car were produced. One was a bogie truck car, 36 ft long, carrying 84 passengers. The other was a single truck car, 27 ft long, designed to carry 62 passengers.

After the routes had been reconstructed and the electric tramway system was progressing satisfactorily, the number of passengers greatly increased, and, by 1910, had reached 125·5 million. In 1908–09, the tramway bill before Parliament led to authority being given for tramways to operate in separate portions of the highway. Liverpool started laying heavier deep-grooved rails to permit tramcars to operate at higher speeds. This work continued up to the commencement of the First World War and then stopped. It recommenced when sanction had been obtained for cars to travel at 20 mile/h on the new rails. In 1932, Liverpool Corporation decided on a policy of tramway modernization. One result was the design and construction of bogie cars known as 'Green Goddesses', because of their olive-green-and-white livery. They commenced service in 1936, and were double-deckers 36 ft long overall. They carried 34 passengers in the lower saloon and 44 in the upper saloon. They incorporated four 40 hp motors, combined with electropneumatic control and weighed nearly 16 tons. Glasgow Corporation purchased 24 of these trams in 1953, and a further 22 in the following year.

In 1938, there were nearly 800 trams in Liverpool. In 1945, some 390 old-type, 4-wheel trams were still in service. There were 178 miles of track in use, carrying 250 million passengers annually. New cars were built after the Second World War at the Lambeth Road Works, fitted with the two 40 hp motors, and equipped throughout with roller bearings. But the motor omnibus was becoming a serious competitor, and the tramway service began to be run down. In its last year of operation, only 26 miles of track were in use. Liverpool's last tram completed its final journey on the 14th September 1957. It was a 1939 streamlined 4-wheel car, no. 293, and is shown in Fig. 10.

LIVERPOOL AIRPORT

Speke Aerodrome – now Liverpool Airport – was one of the municipal airports constructed before the Second World War, and opened in 1933. In 1939, the aerodrome was requisitioned by the Air Ministry, and it was not until 1961 that it was released and control resumed by Liverpool Corporation. Originally it was a grass field aerodrome, but, during the war, three paved runways were constructed. In 1962, the local authority modified the layout for the use of larger and heavier aircraft and two longer runways were made available. Nevertheless, it soon became apparent that, if the airport were to cater for the latest jet aircraft, it would be necessary to increase and improve the airport facilities greatly, and a 7500 ft runway was completed in 1966. When it becomes necessary, the runway can be increased by an additional 3000 ft. This work is intended to be the nucleus of what will eventually be a new airport complex complete with a new terminal building. The new runway was constructed by Percy Trentham Ltd., as the main contractor. Sloan and Lloyd Barnes were appointed consulting engineers. N. H. Stockley, M.I.C.E., M.I.Mun.E., A.M.T.P.I., was the City Engineer under whose direction the work was undertaken.

GROWTH OF MANUFACTURING INDUSTRY

Merseyside and its hinterland have seen a considerable increase in the range of manufacturing industry. Between the wars, there was considerable and persistent unemployment on Merseyside. The need became apparent for new industries to be attracted to the area to provide work for a growing population. Local powers were sought to permit the Liverpool City Council to embark 'on a long-term programme of industrial development and diversification.'[11] These powers were obtained in 1936 when an Act of Parliament enabled the Corporation to develop industrial estates; to construct factories; and lease, sell, or advance mortgages on them. Although a start was made, industrial development was more or less restricted, unless it was required to aid the war effort, until the end of the Second World War. In due course, new industries were established on the perimeter of the suburban areas of Merseyside. Liverpool Corporation was responsible for three new industrial estates. Aintree and Speke were developed before the war, and Kirkby after the war had been concluded.

In the years following the Second World War, Merseyside received massive financial aid from government sources. One result was the emergence of motor vehicle manufacturing plants constructed on a large scale, which are referred to later in this chapter. Nevertheless, the changes brought about by technological advance introduced new problems. Air transport seriously affected shipping companies operating passenger services. Labour disputes increased in some industries. Economic developments introduced financial difficulties, which had serious repercussions, for example, on the Mersey Docks & Harbour Board, which was reconstituted as the Mersey Docks & Harbour Co. The shipbuilding and engineering firm of Cammell Laird of Birkenhead also ran into difficulties. The situation generally was aggravated by the conditions prevailing in the early 1970s, and in 1972, the number of unemployed nationally exceeded one million.

SHIPBUILDING

Shipbuilding on the Liverpool side of the Mersey existed approximately for 100 years, from about the middle of the 18th century onwards. During this period, some fine ships were built, although mainly small in size. In 1850, the declining shipbuilding industry in Liverpool led the Town Council to set up a committee of inquiry with the duty of making recommendations. The principal reason for the decline was the growth of the dock system. Large areas were continually being incorporated into the system. Yards were available for shipbuilding only until the land was required by the dock trustees. This meant that no shipbuilding firm could plan ahead with certainty. The transfer of the dock system to the Dock Board in 1857 brought no change in the situation, and so Liverpool developed into a great port. However, early in the 20th century Henry Grayson set up a shipbuilding company. During its working life the shipbuilding yard constructed tugs, coasters and similar vessels, up to about 3000 tons.[12] As a result of the closure in 1922 of the shipbuilding activities at Garston, the Liverpool side of the river was restricted to shiprepairing, but this was undertaken on a large scale.

Shipbuilding became established early on the Cheshire side of the Mersey. Birkenhead became noted for shipbuilding in 1824, when the Scotsman, William Laird, formed the Birkenhead Ironworks, which later developed into Cammell Laird & Co (Shipbuilders & Engineers) Ltd. Laird constructed the first iron sailing ship, built in 1829, named *Ironside.* The firm pioneered in the construction of steel ships, and in 1838 built the first screw steamship to cross the Atlantic. In due course, the undertaking became one of the largest yards in the United Kingdom. In addition to the large number of ships constructed for British shipowners, including large passenger-liners, the company has also undertaken a considerable amount of work for the Admiralty, including nuclear submarines.

Cammell Laird is also an engine builder and boiler maker. The first marine engine was made in 1857. The company built oscillating and diagonal engines for the early paddle-steamers, and other forms of steam reciprocating engines. Triple-expansion engines were constructed up to 1955; steam turbines, both direct drive, and those with reduction gears,[13] until 1912.

SHIPREPAIRING

Merseyside as a shiprepairing centre was the theme of R. F. Capey's Presidential Address to the Liverpool Engineering Society on the 12th October 1960.[14] When the area developed as a port in the 19th century Merseyside became one of the leading shiprepairing centres. In 1960 some 12 000 craftsmen, representing 15 different trades, were employed in shiprepairing. There were many more semiskilled and unskilled employees. Capey stated that the main tasks of the industry were to fulfil classification requirements, for example, to carry out ship's bottom examination and the withdrawal of the propeller and propeller shaft at stated intervals; to undertake repairs caused by weather conditions, damage and collision, and to carry out surveys.

Changes in shipbuilding construction and the accommodation provided led to corresponding changes in the character of shiprepairing. The author mentioned the introduction of the welded ship, the alloy superstructure, modern furnishings, and the changes made in the design and construction of main and auxiliary machinery. These

changes made the task of the shiprepairer more complex. Prior to 1914 shiprepairing tended to be looked on as a branch of shipbuilding. However, the result of the two World Wars helped to confirm its development as a major industry through the considerable number of ships converted and reconstructed.

In 1958 Grayson, Rollo & Clover Docks Ltd, the firm of which Capey was at that time a director, commenced construction of a dry dock, 800 ft long by 120 ft wide, which proved to be 'the second largest privately-owned dock in the country, and one of the four largest in the British Isles.' Later the company was merged with Cammell Laird & Co. (Shipbuilders & Engineers) Ltd., who also undertake shiprepair work on a considerable scale.

ELECTRICAL ENGINEERING INDUSTRY

Merseyside and North Wales have an interesting history in the development and practical application of electrical energy, made available for domestic consumers, to meet the needs of the port system, and to satisfy the demands of industry and transportation. The background to many of these developments is given in the chapters which follow. The details are based in the first instance, on papers published in the *Transactions of the Liverpool Engineering Society* (later *The Journal).*

Legislation

In this section it will be relevant to provide a brief survey of some of the legislation influencing the generation, distribution and utilization of electrical energy up to nationalization. The development of the electrical supply industry was retarded for many years through legislation. Government policy at the time was to ensure free competition and to prevent monopolies. The result was that the new emerging industry had to compete with the well established coal and gas industries, thus the technical advantages which Britain possessed in the electric lighting field were to some extent lost. Another factor which hindered development was due to lack of co-operation between suppliers of electricity (both local authorities and private companies were involved), because of official policy. Different voltages and frequencies were employed, and the unregulated adoption of either direct current or alternating current, often in adjoining areas.

The Electric Lighting Act 1882 was highly criticised at the time. This Act empowered the Board of Trade to grant provisional orders to undertakings for the supply of electricity in specified areas. It gave local authorities the right to purchase the undertakings and operate them at the end of 21 years. This was a major factor in delaying development for some years. The amending Electric Lighting Act 1886 was passed as a result of informed technical opinion and gave more acceptable conditions. The period of 21 years was extended to 42 years.[15]

Developments depended on the Board of Trade as the authority for granting powers for the erection of power stations and the provision of underground cable systems. The Electric Lighting (Clauses) Act 1899 provided an up-to-date set of regulations etc. Meanwhile, the extending use of high voltage alternating-current led to a small number of private companies being granted the right to supply electrical energy for all time. W. E. Swale credits 'the genius of S. Z. de Ferranti' for these technical developments.[16] Bulk supplies and collaboration between local authorities in the supply of electricity were permitted in the Electric Lighting Act 1909. Following the 1914-18 War, the Electricity (Supply) Act 1919 was followed by the Electricity (Supply) Act 1922, which dealt with the reorganization of the public supply of electricity, including the establishment of the Electricity Commission for promoting, regulating, and supervising the supply of electricity. The aim at this period was the establishment of Joint Electricity Authorities. In 1886 output was about 1·5 million units. By 1922, it had risen to nearly 119 million units.

The Electricity (Supply) Act 1926, formulated as a result of the Weir Report (1926), led to the setting up of the Central Electricity Board in 1927. The Act ensured that future developments would be considered on a national basis, and the CEB instituted the National Grid. The next major step followed the passing of the Electricity Act 1947 which resulted in the nationalization of the industry from the 1st April 1948. Some 600 'authorized undertakings' became the responsibility of the British Electricity Authority (later the Central Electricity Authority, and now the Electricity Council and the Central Electricity Generating Board) and the Area Boards. At this stage, both

the Central Electricity Board and the Electricity Commission were abolished.

The Merseyside & North Wales Electricity Board (MANWEB), with headquarters at Chester, has been responsible for electricity supply in an area of some 4700 square miles since nationalization. The area involved includes Liverpool, South-West Lancashire, the Wirral, parts of Cheshire, and North Wales. Forty-four local authority and other undertakings were taken over by MANWEB, either as a whole or in part, and divided into four Subareas.

Electrical Engineers in Manufacturing Industry

In the electrical engineering field Merseyside gained an international reputation through the products of the former Automatic Telephone & Electric Co. of Liverpool, which was formed in 1912. British Insulated Cables Ltd. was established at Prescot in 1891 as the British Insulated Wire Co. Ltd. In 1945 the 'BI' as it became known, merged with Callender's Cable & Construction Company Ltd., and the present title of British Insulated Callender's Cables Ltd. was adopted. The English Electric Co. was formed in 1918, by the amalgamation of a number of old-established engineering firms. In 1942 the company acquired D. Napier & Son Ltd., which included its works in Liverpool. In recent years there have been mergers which have reduced considerably the number of firms, aimed at creating large viable groups. The Plessey Company Ltd. took over the Automatic Telephone Company, and the English Electric Co. was taken over by the General Electric Co. in 1968. Brief historical sketches of some of these companies appear elsewhere in this book.

The nationalized industries functioning in the area include the Merseyside & North Wales Electricity Board mentioned previously, and the Central Electricity Generating Board.

In addition to the larger companies mentioned above, there are many medium-sized and small firms who have made or are making a valuable contribution to the work done by the electrical engineering industry. Some examples are given below:

H. T. Boothroyd Ltd., of Bootle, a one time flourishing company, included E. W. Ashby, H. E. Dance and A. Milton, members of the Centre, on their list of apprentices who successfully served their time with the company.

Brookhirst Switchgear Ltd., of Chester, was formed in 1898. The company produced a variety of control systems, for example, for heating and airconditioning the House of Commons, motor controls for large liners, and for power stations, both of conventional and of nuclear design on a worldwide basis. In 1958, Brookhirst and the Igranic Electric Co. of Bedford amalgamated to become Brookhirst Igranic Ltd. (BHI). The Chester factory closed in 1968 and the firm's main production was concentrated at Bedford. BHI is a member company of Cutler-Hammer Inc. of Milwaukee.

G. P. Dennis Ltd., of Liverpool, was established in 1920, and continues to manufacture switchgear equipment and related products. The Managing Director presented the G.P. Dennis golf trophy which is competed for annually in aid of the Benevolent Fund of the Institution of Electrical Engineers.

Cable makers who were once prominent include the Liverpool Electric Cable Co. Ltd., of Bootle, founded in Liverpool in 1901, makers of paper insulated and lead covered, and rubber covered cables. The Mersey Cable Works Ltd., of Bootle, was established in 1926, and manufactured electric cables. The St. Helens Cable Co. was another well known firm.

Electrical contracting has always been an essential activity in electrical engineering. A wide variety of firms have undertaken, and are undertaking this work on Merseyside and North Wales.

Chester Electricity Undertaking

The City of Chester has, with Liverpool, been one of the two main venues for meetings of the Mersey & North Wales Centre of the Institution of Electrical Engineers for very many years. Therefore it is appropriate to give a summary of the setting up and development of the Chester Electricity Undertaking, which celebrated its Jubilee in 1946.[17] Two years later, it was absorbed as a nationalized undertaking.

The Chester Electric Lighting Order 1890 gave the Corporation authority to supply electricity within the sanitary district of the City of Chester. The plant and mains were installed by Thomas Parker Ltd., under the direction of Professor Kennedy, and inspected and approved by Lord Kelvin in 1896. Electricity was used solely for lighting purposes when it was introduced. The Royalty Theatre became the undertaking's first consumer. The original power station was constructed at New

Crane Street in 1895. Direct-current generators, driven by reciprocating steam engines, were employed, as shown in Fig. 11, supplying current at a pressure of 210/420 V. By 1910 the Crane Street Works had reached maximum capacity, and, at this stage the possibility of utilising water power was considered, resulting in the construction of the Hydro Station, shown in Fig. 12. This work was started on the site of the Old Dee Mills. The plant consisted of three vertical (2 – 225 kW, and 1 – 185 kW) d.c. generators driven by vertical water turbines as shown in Fig. 13. The station was officially opened in 1913.

To meet peak loads batteries were installed at the Crane Street Works and recharged at night by the Hydro Station. In 1932, a motor convertor was provided at the Hydro Station to convert direct current into 3-phase a.c., to meet the changing conditions in distribution. The energy generated averaged 1¼ million units per annum which, at the time of installation, provided about 40% of the total demand. By 1946 this output represented only some 2¼% of the total requirements. In 1932 the Corporation purchased the Queen's Ferry Power Station. The plant consisted of 3 – 1500 kW, and 1 – 1000 kW turboalternators generating 3-phase a.c. at 440 V, 50 Hz. Dual 33 kV overhead transmission lines were erected.

GROWTH OF CHESTER ELECTRICITY UNDERTAKING[18]

Year ended 31st March	*Effective capital expenditure* £	*Total units sold*	*Price per Unit* d	*Maximum demand supplied* kW	*Number of Consumers*
1897	24 781	50 289	3·785	131	—
1900	65 766	617 792	3·600	529	421
1910	122 380	1 869 073	2·225	1 400	1 195
1920	169 987	3 093 613	2·429	1 764	1 990
1930	547 717	10 164 001	1·914	5 346	7 588
1940	908 553	34 078 536	1·193	13 002	21 962
1946	989 543	55 549 275	1·200	19 278	23 547

The original generating plant at the New Crane Street station was ultimately replaced by rotary convertors, and later by mercury arc rectifiers until the increase in the use of alternating current made the converting plant redundant. The changeover from d.c. to a.c. commenced in 1930. The new supply was provided at 230 V, single-phase, and 400 V, 3-phase. Rural areas were supplied by means of 6600 V and 230/400 V, 3-phase overhead lines. The growth of the Chester Electricity Undertaking can be seen in the statistical summary shown on page twenty-three.

The pioneer whose influence was felt during 42 of the 50 years dealt with in the above review of the Chester Electricity Undertaking was S. E. Britton, (Fig. 14), who was appointed City Electrical Engineer in 1904. He remained in office until his death in 1946, when he was 70 years of age. Unfortunately, he did not live to see the Jubilee of the undertaking. Reference is made to Britton later in the book, and in particular to his interest in rural electrification. He was an active member of the Mersey & North Wales (Liverpool) Centre of the Institution of Electrical Engineers and was chairman during the 1928–29 session.

Nuclear energy

The United Kingdom Atomic Energy Authority was set up in 1954. One of its functions is the development of nuclear energy for the generation of electricity. The Authority's Reactor Group is established at Risley, near Warrington. The former Production Group Headquarters at Risley, and the uranium enrichment factory at Capenhurst, Cheshire, were transferred to a new company, British Nuclear Fuels Ltd. in 1971.

Generating schemes in North Wales

Three hydroelectric power stations were constructed by the former North Wales Electric Power Co. at Dolgarrog, Cwm Dyli, and Maentwrog, respectively. The energy generated was supplied to industrial and domestic consumers for the whole of North Wales and Anglesey. The energy required by industry was used mainly for mining coal and metals; slate and granite quarrying, and steelmaking.

Britain's first pumped storage scheme was constructed near Blaenau Ffestiniog, in Merionethshire. Work commenced on the site for the Ffestiniog Power Station in 1957. The first unit was commissioned in 1961, and the fourth and final unit in 1963. The upper reservoir, incorporating the Stwlan dam, is situated 1000 ft above the lower reservoir and power station shown in Fig. 15. The plant consists of four vertical 90 MW generator/motor units, each coupled to a Francis turbine, and by clawtype coupling to a double-suction 2 stage storage pump. Overhead lines at 275 kV connect with the Grid system at the Trawsfynydd nuclear power station. The latter, shown in Fig. 16, is the CEGB's first inland nuclear power station. Construction commenced in 1959 and power began to be supplied to the national grid system in 1965. The station has a generating capacity of 580 000 kW. Power is generated at 132 000 V, 275 000 V, or 400 000 V over the grid, or supergrid networks.

Wylfa Power Station on Anglesey was the eighth nuclear station to be brought into operation by the CEGB. It began to feed electricity into the Grid in 1971, and was finally commissioned in 1972. The reactor building is shown in Fig. 17. Two reactor units and four turbo-alternators, each of 335 MW, transmit electricity to the Grid system by a 400 kV line 70 miles long.

The three stations mentioned are the responsibility of the North-Western Region of the Central Electricity Generating Board. The necessary approvals are now being sought for the construction of a hydroelectric pumped storage scheme incorporating an underground power station beneath the disused Dinorwic slate quarry, sited near Llanberis in Caernarvonshire. The station will have a capacity of more than 1·4 million kW.

Broadcasting

The British Broadcasting Corporation celebrated its jubilee in 1972. It was on the 14th November 1922 that the British Broadcasting Co. first broadcast from Marconi House, London, call sign 2LO. Regular television broadcasts commenced in 1929. Further details of these developments will be found elsewhere in the book.

OTHER INDUSTRIES

Merseyside and its hinterland have seen a considerable increase in the range of manufacturing industry, particularly since the Second World War. The salt deposits of Cheshire provided the raw material which resulted in the concentration of the production of heavy chemicals in South Lancashire and North Cheshire. The United Alkali Co. Ltd., with headquarters in Liverpool, established a central research laboratory in Widnes in 1892. This company amalgamated with Brunner, Mond and Co., Nobel Industries, and the British Dyestuffs Corporation, in 1926, to form Imperial Chemical Industries Ltd. In 1964, the Mond Division was formed with headquarters at Runcorn, responsible for the production of organic chemicals.

Joseph Crosfield of Warrington commenced making soap in 1815, and William Gossage of Widnes started in the same business in 1855. Both concerns became part of Lever Brothers Ltd. in 1919. The latter company was founded in 1885 and produced household soaps. Unilever was formed in 1929 through the merger of the Margarine Union, a group of companies based in the Netherlands, and Lever Brothers Ltd. The main interests of Unilever are foods, detergents, toilet preparations, and chemicals.

Coal mining and textiles became important industries in Lancashire in the 19th century and the first quarter of the 20th century. Wigan was a leading coal mining centre. St. Helens is noted for its glass industry which commenced in the 18th century. Pilkington Brothers, with its extensive research and development centre at Lathom, went public in 1970, after 144 years of family control, and continues to be a leader in the glass industry. In 1952 the ideas were conceived which led to the revolutionary float glass process. St. Helens is also an important coal mining area.

Included in the firms in the engineering industry operating in the area at the present time are Lockheed Precision Products, specialists in precision hydraulic engineering; Whiteley, Lang & Neill Ltd., tool and die manufacturers; Lucas Gas Turbine Equipment Ltd., manufacturers of various products for the aircraft industry, together with its subsidiary Lucas Industrial Equipment Ltd.; and Yorkshire Imperial Metals Ltd., producers of copper tubes.

The food industry is well represented and includes sugar refineries, processed cheese, biscuit manufacture, and quick-frozen foods. The pharmaceutical industry is strongly established on Merseyside and there are manufacturing chemists providing a comprehensive range of products. Papermaking on a large scale is undertaken at the Bowaters United Kingdom Paper Co's Mersey Mills at Ellesmere Port.

The motor industry is a relative newcomer to Merseyside and first

made its appearance in 1960 when the Ford Motor Co. established itself at Halewood. British Leyland's Standard-Triumph manufacturing plant at Speke was erected later and further plans for expansion were published in 1969. Both concerns are concentrated on the northern bank of the Mersey. Vauxhall Motors have a factory at Ellesmere Port on the south bank of the river. All three plants constituting the motor industry on Merseyside have been built as large manufacturing units, taking advantage of the port and transport facilities available in the area for distributing their products, both at home and to export markets.

In addition, there are also firms producing component parts and accessories. For example, AC-Delco, at Kirkby, produces fuel pumps, instruments, body components, and electrical equipment. The Dunlop Rubber Co. at Speke manufactures tyres for a wide range of motor vehicles, and other rubber goods. Another firm in the industry is Massey-Ferguson Ltd., at the Knowsley Industrial Estate, manufacturers of various forms of industrial prime-movers, and constructional machinery, such as diggers and loaders.

CHAPTER 2

DEVELOPMENT OF TECHNICAL AND HIGHER EDUCATION

Matters concerning the education, training and professional status of engineers were considered from time to time in papers read at meetings of the Liverpool Polytechnic Society, and the Liverpool Engineering Society.[1] Some details of these two societies are included in Chapter 3. The education and training of electrical engineers has, of course, been one of the primary objectives of the Institution of Electrical Engineers, at both national and local levels.

This chapter surveys the early development and growth of technical and higher education in the area covered by the Centre's boundaries, but particularly in Liverpool, from the beginning of the 19th century, when the desire for self-knowledge emerged and flourished on a nationwide scale. Primarily the cause was the rapid extension of scientific and technical knowledge, coupled with its application in some old and many new industries. One aspect of this advance was the setting up of the Mechanics' Institutions early in the 19th century all over the country. There was also the growing demand for the higher education of women in the latter part of the century. But the new and growing interest in learning was not confined to science and technology, it included literature and arts subjects. Liverpool in particular, was very much involved in these early developments.

The movement commenced in the latter half of the 18th century when the need for books became apparent. Societies were formed which were essentially libraries, or which included libraries, because no public libraries existed. The Athenaeum was founded in Liverpool in 1798 in Church Street and moved to its present accommodation in Church Alley. A library was established from the beginning. In addition to its value at the present time it houses a collection of books covering

a wide range of interests. The Lyceum, which opened in Bold Street, Liverpool, in 1803, also included a library, formerly known as the Liverpool Library, a subscription library formed in 1758, and retained up to the Second World War. The Liverpool Literary and Philosophical Society, another form of cultural institution, was founded in 1812.

Another body, which continues to function, is the Liverpool Philomathic Society which was formed in 1825 in the Royal Institution. It was set up to encourage learning by discussion, and is probably one of the oldest debating societies in Britain.[2] At one period the society maintained a library and a catologue was issued in 1879.

WILLIAM ROSCOE AND HIS CIRCLE

The institutions mentioned above, and others to be described, were founded by a group of men of whom William Roscoe, Fig. 18, is the best known. They were pioneers whose energy and enthusiasm in the educational field were to exert a considerable influence on developments in the years ahead.

William Roscoe was born in 1753 at the Old Bowling Green House, Mount Pleasant, Liverpool. The son of a gardener, he was largely self-taught, and became primarily a historian. He was also a minor poet. He helped to found two societies for the encouragement of the arts, painting and design, and lectured on the history of art. In 1799 Roscoe joined a Liverpool bank and became a partner. Some years later he was elected an MP for Liverpool. Unfortunately, Roscoe's bank ran into difficulties and eventually went bankrupt. In an attempt to satisfy the claims of creditors he disposed of his fine library of books and collection of paintings. His friends came to his aid and helped him financially and this enabled him to pursue his interests in his old age. Roscoe died in 1831 and was buried in the grounds of a chapel in Renshaw Street, Liverpool.[3]

An active member of Roscoe's circle who is mentioned in this chapter is Thomas Stewart Traill, who was born in Orkney in 1781. He attended the University of Edinburgh and graduated in medicine in 1802. He moved to Liverpool in the following year and practised until 1832, when he was appointed professor of medical jurisprudence at Edinburgh. Traill was a keen lecturer and maintained a great interest in what we now refer to as further education and adult education. He was one of the founders of the Literary and Philosophical Society of Liverpool, and became the Society's first secretary. He also helped to establish the Liverpool Royal Institution, and became a leading figure in setting up and developing the Liverpool Mechanics' Institution. He died in Edinburgh in 1862.[4]

LIVERPOOL ROYAL INSTITUTION

The Royal Institution[5] has been described by Prof. Thomas Kelly as 'the most famous adult educational organisation of 19th-century Liverpool'.[6] The name of the person who conceived the idea has never been determined. Dr. Traill claimed that he drew up the original plan. William Corrie, a Liverpool broker, took a leading part in the proceedings, and the local garrison commander, Maj.-Gen. A. Dirom was also a contender for the position.

The views of the gentlemen interested in founding the Institution were made public in May 1814. It was to be established primarily for 'the promotion of literature, science and the arts'.[7] It was considered desirable to induce knowledgeable men to reside in Liverpool and become teachers of scientific and other subjects. A fund was to be set up which would remunerate them for providing instruction and delivering lectures. It was intended to include teaching facilities, to organize public lectures, to form a library, to set up an art gallery and museum, to provide an observatory and a laboratory. A subordinate aim was to encourage societies 'who may unite for similar objects'.[8] In course of time a number of societies made the Royal Institution their headquarters, or used it as a meeting place. When the Mersey & North Wales Centre of the Institution of Electrical Engineers became active, many meetings were held at the Royal Institution, and a close link was established.

The proposal made progress when a suitable building was found in Colquitt Street. On the 25th November, 1817, the Liverpool Royal Institution (Fig. 19) was formally opened. The following gentlemen formed the Committee at the inauguration: William Roscoe (Chairman), John E. Gladstone (Deputy Chairman), Wm. Corrie, W. Wallace Currie, Fletcher Raincock, B. A. Heywood, Jas. Gerard, MD, John Yates,

Tho. Earle, Wm. Wainewright, Tho. Stewart Traill, MD, J. Vose, MD, Charles Turner, Jona. Brooks and Isaac Littledale.

William Roscoe delivered an address entitled: 'On the origin and vicissitudes of literature, science and art, and their influence on the present state of society,' Included in his survey is the following statement, which indicates his advanced thinking:

> 'Education is the proper employment, not only of our early years, but of our whole lives; and they who, satisfied with their attainments, neglect to avail themselves of the improvements which are daily taking place in every department of human knowledge, will in a few years have the mortification to find themselves surpassed by much younger rivals. In order to afford the best possible opportunity of preventing such a result, it is the avowed object of this Institution, not only to establish a system of Academical Education, but to draw from every part of the United Kingdom the best instructors that can be obtained, on those subjects which are of the first importance and the highest interest to mankind.'[9]

Roscoe became President of the Royal Institution in 1822. A Royal Charter had been granted in the previous year, although permission had been received to employ the title Royal some years earlier. The institution was successfully launched, and the lecture courses were established. The two day schools providing instruction in classics and mathematics were opened in 1819. Some years later the schools amalgamated and, because of the demand for places a new building was constructed on the opposite side of Colquitt Street, and opened in 1837. The Royal Institution schools made an extremely useful contribution to grammar school education during a period when such facilities were scarce. They continued to exist until 1892, when they closed because of competition from new schools that had been built in the suburbs.

From the beginning of the project a number of proprietors considered that the provision of lectures was the institution's primary objective. The scheme of lectures was ambitious embracing philology, history, moral philosophy and political economy (including commerce); chemistry, natural history, (including geology and minerology), natural philosophy (the mechanical branches to be illustrated by models of the most approved machinery); botany, horticulture and agriculture; anatomy, physiology, surgery and medicine.

There was a constant demand for science subjects by medical students. Courses were organized and continued until the Liverpool Medical School was set up in 1834, a development which paved the way for the founding of the Faculty of Medicine in the University of Liverpool.

Lectures were given in zoology, geology, astronomy, and occasional courses in other scientific subjects, including one on the 'Present state of electricity' by a Dr. Ritchie, in 1833. There were also many lectures on arts subjects. Courses on architecture, painting and music were provided. However, by the early 1840s the numbers dwindled to the extent that the lecture courses were abandoned.

In his book on the Royal Institution, Prof. H. A. Omerod comments that it 'had developed within itself at least the nucleus of a modern University College, with separate faculties of medicine, science and arts, which, if circumstances had been more favourable, might well have come into existence much earlier than was actually the case'.[10]

Although an observatory was never constructed, the library prospered. The Gallery of Art and the Museum of Natural History were both highly successful and popular at a time when such amenities were generally lacking. However, in 1845 the Museums Act was passed and this paved the way for local authorities to establish museums from the levy of a special rate. When Liverpool Corporation built the Central Libraries, the Museum and the Art Gallery, the Royal Institution could no longer compete with the facilities that could be provided from public funds. The museum collections were disposed of, and a considerable portion of the art collection was deposited with the Walker Art Gallery. The library was transferred to the University College in 1894. By the end of the century the only function that remained was the increasing use of the Institution's accommodation by mainly cultural and scientific societies, and later by engineering institutions. In 1948, the property was transferred to the University of Liverpool and the existence of the Royal Institution as a chartered body was terminated.

This brief account of the history of the Royal Institution illustrates the effect of changing conditions. At the same time it must be recognised that the Institution's financial resources were always inadequate to implement fully the plans originally conceived. To bring the story up to date, in 1960, the Royal Institution building became the main centre for the University of Liverpool's Department of Adult Education & Extra Mural Studies (now the Institute of Extension Studies). The year 1967 saw both the 150th anniversary of the foundation of the Royal Institution, and the 100th anniversary of the provision of university work in Liverpool.

LIVERPOOL MECHANICS' AND APPRENTICES' LIBRARY AND BROUGHAM INSTITUTE

The Liverpool Mechanics' and Apprentices' Library was opened in July 1823, two years before the foundation of the Mechanics' School of Arts, which evolved into the Mechanics' Institution. The person who must be credited with its establishment is Egerton Smith, who was at that time editor of the *Liverpool Mercury*. The setting up of the library was first suggested in a letter received from a Mr. Noab, the Sheriff of New York, recommending the formation of an Apprentices' and Mechanics' Library in Liverpool, based on the scheme adopted in New York and other cities in the United States. The proposal was raised in the local press and then referred to the Guardian Society, instituted for the protection of tradesmen against scoundrels, and by a show of hands the master tradesmen of Liverpool (who would be affected by the opening of the library) unanimously approved the proposal. Shortly afterwards about 1200 volumes and numerous pamphlets (including some presented by the committee of the Liverpool Library) were made available. Great care was taken to exclude 'improper' books, for example, those concerned with party politics and contraversial theology. On the other hand, every encouragement was given to 'the introduction of works of morals, elementary science, biography, voyages and travels, poetry and exceptional works of imagination'.[11] Owing to the need for economy no printed catalogue was prepared at this stage, but some of the apprentices produced a catalogue which was 'done in a style of neatness that reflects the greatest credit on themselves'.[12]

In 1825 it was reported that although there had been a rapid increase in the number of readers, funds fell short of expectations. Readers finding their requirements limited 'came forward spontaneously, and almost unanimously, with an offer to contribute one half-penny per week . . . many, indeed, were anxious to subscribe one penny per week'[13] but the latter sum was discouraged as the former amount was considered to be within the reach of all concerned. During the year nearly 650 volumes, 'very few which can be considered refuse', were donated, partly through house-to-house collections in the principal streets, which the library organized. It was also noted in the report that *The Mechanics' Magazine* was in great demand. It was a new kind of journal written and published essentially for mechanics. It was first issued in 1823.

The work of the library continued to develop. Some years later it commenced a fruitful association with the Brougham Institute, which provided amenities and facilities complimentary to those available in the library. The Institute was formed in 1836 in Lawton Street, Liverpool.[14] It was named after Lord Brougham who was keenly interested in the subject of education. He collaborated with Dr. G. Birbeck in helping to set up various mechanics' institutions throughout the country. In 1825 he had brought forward bills for developing a system of national education, but the ministry in which he served was defeated, and no further action was taken.[15]

The Brougham Institute consisted of a reading room and made provision for lectures, mutual instruction, discussion groups and other classes. It was founded 'for the purpose of diffusing knowledge amongst the working classes for tenpence per month, two shillings per quarter or seven shillings per year'.[16] The reading room was capable of accommodating 200 readers. It contained a small library but the main attraction was the London and Liverpool newspapers and periodicals published in the United Kingdom.

The Free Public Library was opened in 1852 and in the following year both the Liverpool Mechanics' and Apprentices' Library and the Brougham Institute ceased to exist.

MECHANICS' INSTITUTION MOVEMENT

The movement for educating the adult working classes commenced with the foundation of the Mechanics' Institutions in the early twenties of the last century. The initiative was taken, not by the working classes themselves, but by professional men and members of the governing classes. Nevertheless, many workers appreciated that educational opportunities could lead to better jobs and an improvement in their standard of living. The need for better educated work people ran parallel with advances made in science and technology, following the impetus given to these developments by the Industrial Revolution of the 18th-century. Mechanics' Institutions were established in many towns and also in some rural areas in Great Britain and the movement also prospered in Ireland. These institutions paved the way for the development of technical and, ultimately, higher education that we know today.

The Mechanics' Institutions followed a general pattern. They normally provided facilities for lectures, a reading room and library, and a museum, and, in some instances, a workshop was made available. Unfortunately, the lack of provision of general education at the time did not always permit the potential of the institutions to be realized. Many of them failed, and their activities declined. A small number flourished and some eventually developed into technical colleges. At least one became a university institution. By the middle of the 19th century, those attending the Mechanics' Institutions tended to be lower middle-class, rather than working men and, as a result, technical instruction grew less and the courses evolved into more liberal and popular subjects. Notwithstanding the changed conditions, the movement created a situation which aided the introduction and development of modern technical education, and of adult education generally.

LIVERPOOL MECHANICS' SCHOOL OF ART
LATER KNOWN AS MECHANICS' INSTITUTION

The founding of the Royal Institution in Liverpool in 1814 had resulted in the establishment of a boys' school in 1819. Five years later the proprietors became interested in opening a Mechanics' Institution. They felt that the Liverpool Mechanics' and Apprentices' Library, which had been opened in the previous year (1823), would provide a foundation on which to build and expand. The formal proposal was delayed until 1825 when Dr. T. S. Traill, a Vice-President of the Royal Institution, became very enthusiastic, and made a determined efforts to ensure the success of the undertaking. In an address given on the formation of a Mechanics' Institute or School of Arts, at the Music Hall, Liverpool, in June 1825, he said:

> 'The object for which you are here assembled is to ascertain the practicability of establishing in this town a School of Arts, in which the labouring classes of our great and industrious community may be enabled, at an easy rate, to obtain instruction in the science most immediately connected with their daily occupations'.[17]

He reminded his audience of the large number of iron foundries and forges, with their steam engines and other pieces of intricate machinery, which existed in the area. It was also a 'centre of one of the districts in England most celebrated for the manufacture of watchwork'.

Traill informed his listeners:

> 'The chief subjects on which instruction is proposed to be delivered in the School of Arts, are – Mathematics, as connected with the Mechanical Arts, various branches of Mechanical Philosophy, Chymistry *(sic)*, applied to the arts; Architecture; and to those who show any taste for it, probably Perspective Drawing, and the very useful art of representing machines and their parts on paper'.

The speaker stressed the need for a good library and the provision of a laboratory 'for the performance of simple experiments by the artizans themselves'. He suggested that a museum would be desirable to house models of machines. The school was to be governed by a committee made up 'from all classes connected with it', and the members would be elected annually. Traill covered many of the practical issues and ended his address by quoting 'Knowledge is power'. It was estimated that a sum of £3500 would be required to finance the proposal, and, for this purpose a subscription list was opened.

The Liverpool Mechanics' School of Arts was inaugurated in 1825.[18] William Huskisson, President of the Board of Trade, and a keen supporter of the new movement was elected the first President.[19] The school was housed in a disused Chapel on the site where the Education Offices now stand in Sir Thomas Street. In 1832 the name The Liverpool Mechanics' School of Arts was changed to The Liverpool Mechanics' Institution. Unfortunately, its growth was restricted through lack of funds, but a day school was opened in 1835. The financial situation gradually improved and the free transfer of land from the Corporation to the Trustees permitted the latter to erect a

permanent building which later became the Institute High School for Boys. Lord Brougham laid the foundation stone in 1835 and the new building was opened two years later.

The evening classes were considered the most important section of the work and provided further education for young men who were employed in the day time. These classes commenced when the institution was founded and continued until 1894. They were transferred to the new Mount Street building when it became available, and the syllabus of classes was extended to include arts subjects, vocal music and dancing. However, it was not until 1844 that courses were organised to permit students to work progressively.

For a few years lectures were given on a voluntary basis, but, in 1832, professional lecturers were engaged. The lectures proved very popular initially, but during the middle of the century, following a decline in numbers, the lecture programme was discontinued for a time, and a later attempt to revive it failed. The library was considered to be of fundamental importance, and members paid an annual subscription. The effect of the opening of the Free Public Library in 1852 had the same effect as it had in other cases. The use of the library diminished and by 1882, it had more or less disappeared.

Following the opening of the Day School in 1835, a second school, the High School for Boys, was founded at Mount Street in 1836, and in 1844 the High School for Girls was established at Blackburne House. The schools were great successes, both educationally and financially, and developed into permanent institutions. Later they were taken over and maintained by the local education authority.

The changing character of the institution, particularly with regard to the work of the Day Schools, led to another change of name and so, in 1856, The Liverpool Mechanics' Institution became The Liverpool Institute and School of Art. Following the passing of the Education Act of 1902, the Directors, in 1903, offered to transfer the Liverpool Institute to the City Council, and negotiations were formally completed in 1905.

In surveying the history of the Liverpool Mechanics' Institution, there is no doubt that it succeeded in meeting and satisfying a real need. Although the setting up of the Day Schools changed its character, in the final assessment they made an outstanding contribution to the development of secondary education.

QUEEN'S COLLEGE

In 1857 the Directors of the Liverpool Institute set up a new department, designated Queen's College.[20] Lord Brougham took the chair at the formal opening. The aim was to provide facilities for boys to continue their education at university level, either independently or in association with the University of London. The college was authorized to grant the necessary certificates to qualified students preparing for the examinations conducted by the University, to comply with the regulations, but later withdrawn. Both day and evening classes were provided, but the former ceased in 1870, owing to lack of support. In 1865 lectures in engineering subjects were made available at evening classes which grew in popularity. In 1866 the college had developed faculties of arts and science, at a time when facilities of this kind were almost unknown. The new venture continued until 1881, when financial difficulties, primarily lack of endowments, led to closure of the college. Existing classes were amalgamated with other classes held at the institute.

WOOLTON MECHANICS' INSTITUTE

The history of the Woolton Mechanics' Institute is interesting because it is concerned with a small urban district, and the demand for the institute came from the workers themselves.[21] The project was strongly supported by the Rev. Dr. W. Shepherd, the minister of Gateacre Chapel, and his copastor, Mr. Lewis, who was prepared to play an active part in the work of the proposed Institute. Sufficient funds were raised to construct a building and the foundation stone was laid in 1847. The structure was completed in the following year, and was formally opened in 1849. Meanwhile a boys' school and a girls' school had been set up in conjunction with the institute.

The aims of the institute were to provide a cultural influence, to make available a centre for like-minded groups, and to provide various levels of instruction for the local community. The facilities included a reading room and a circulating library. Lectures were given on a small number of topics but interest in them soon declined. The schools were not very successful, and the fees were insufficient to pay the

teachers satisfactorily. In 1862, the Rev. G. Beaumont, a later minister of the Gateacre Chapel, used his influence to revive the work of the institute and a number of activities were recommenced, including evening classes and public lectures. Various local societies used the building for their meetings and the educational work became more technical in character. These classes continued until 1904 when the County Council assumed responsibility for education provision in Woolton. In due course, Woolton became part of the City of Liverpool, and the building was purchased by the Corporation. In 1928 the Woolton Institute ceased to exist. A sum of money was donated to the University of Liverpool to provide an entrance scholarship to be known as the Woolton Mechanics' Institute Scholarship.

OTHER MECHANICS' INSTITUTIONS

There were a number of other Mechanics' Institutions in the area, for instance, the Warrington Mechanics' Institution was set up in 1825 and existed until about 1868. Various minute books, rules and orders, or Bylaws, have been preserved. The Northern Mechanics' Institution was founded in Liverpool in 1839 but lapsed after three years, probably owing to lack of accommodation. It was revived in 1849 but appears to have been dissolved a year or so later. Birkenhead Mechanics' Institution was active from 1849 to 1851. The Bootle Educational Institute was founded in 1849, and continued to function until 1860.

THE UNION OF LANCASHIRE AND CHESHIRE INSTITUTES

The growth of Mechanics' Institutions and similar societies led to the setting up of various bodies in different parts of the country to promote some form of systematic co-operation between them, and to help to further their objectives. The first of these bodies was established in 1837 in Yorkshire, and was known as the West Riding of Yorkshire Union.

The Union of Lancashire and Cheshire Institutes (ULCI), as it was finally named, was founded in 1839. It was first known as the Manchester District Association of Literary and Scientific Institutions.[22]

Richard Cobden played an influential part in its inauguration. Its purpose 'was to organize systematic courses of lectures for the associated institutions'. It was reorganised in 1847 under the title the 'Lancashire and Cheshire Union of Mechanics' Institutions'. Nine years later the name was again changed and became 'The Institutional Association of Lancashire and Cheshire'. A competitor appeared in the form of the East Lancashire Union of Mechanics' and other Institutions, which operated on similar lines, utilizing organizers and operating a scheme of examinations. In 1863 the management of the association was revised and the union was dissolved. The constituent institutions thereupon joined the association which became the Union of Lancashire and Cheshire Institutes, as it is known at the present time.

The function of the Union gradually changed and the first formal conference with teachers was held in 1868. Following the passing of the Technical Instruction Acts, and the Education Act of 1902, the union largely became a federation of local education authorities in the two counties, North Wales, and the Isle of Man, who were interested in further and higher education. In 1914 a revised constitution confined future activities to part-time day and evening classes. The union's work is now very extensive in the examinations field which includes a number associated with engineering at ONC and HNC levels, including electrical engineering.

LIVERPOOL SCHOOL OF SCIENCE; OPERATIVES' SCIENCE CLASSES, AND LIVERPOOL SCHOOL OF SCIENCE, TECHNOLOGY AND ART

There was a constant demand for facilities for both technical and higher education in Liverpool, supported by other sections of the Merseyside community, during the second half of the 19th century. Some progress was made and the tenacity of the enthusiasts supporting the various schemes culminated in the establishment firstly, of the university college, and secondly of the municipal technical school.

The initial proposal was made in 1861 when a committee was formed following a meeting in the Liverpool Town Hall, under the chairmanship of the Mayor (Mr. S. R. Graves), to organize various classes.

Later, in the same year, the Liverpool School of Science was inaugurated at a meeting held at St. George's Hall. In 1872, a separate scheme known as the Operatives' Science Classes was organized, later referred to as the Science and Art Classes. The School of Science was supported to some extent by the City Council after the passing of the Technical Instruction Act of 1889, which provided certain local authorities with powers to provide technical education. Funds were made available during the following year by the Local Taxation (Customs & Excise) Act, through a share of the 'whiskey money' which could be allocated to technical education. The so-called whiskey money resulted from a decision of the House of Commons not to use the tax imposed on alcoholic liquor to compensate publicans who lost their licences under a Government Bill aimed to reduce the number of public houses. The Technical Instruction Act permitted county and county borough councils to set up Technical Instruction Committees to provide and adminster the instruction organized.

From about 1890 to the beginning of the First World War, technical institutes, colleges and polytechnics were founded in many parts of the country. The classes were held mainly in the evenings. In Liverpool the School of Science and the Science and Art Classes amalgamated to form the Liverpool School of Science, Technology & Art. It soon became apparent that the work developing at the school required purpose-built accommodation to permit it to function efficiently.

During this period, one person whose influence made a valuable contribution to the development of technical education on Merseyside was William Hewitt, B.Sc.[23] He was born at Keighley in 1851 and graduated at the Royal School of Mines at South Kensington, where he studied under Prof. T. H. Huxley. In 1877, he became the first science demonstrator to be appointed by the Liverpool School Board, and became responsible for organising science teaching in the schools. Following the passing of the Technical Instruction Act 1889, Hewitt was appointed Director of Technical Instruction in 1892. Eleven years later, he was designated Director of Technical Education, and served in this capacity until his retirement in 1916.

Mr. Hewitt was responsible for establishing a number of branch technical and commercial institutes, and junior day technical schools at Toxteth, Walton and Old Swan. He was directly concerned with the establishment of the Municipal Technical School, later the College of Technology, and until his retirement his duties as Director of Technical Education included acting as Principal of the school.

MUNICIPAL TECHNICAL SCHOOL TO REGIONAL COLLEGE OF TECHNOLOGY

In late October 1901, the *Liverpool Echo,* the *Liverpool Daily Post,* and the *Liverpool Review,* published many columns describing the new Central Technical School, designed by Mr. E. W. Mountford, F.R.I.B.A., of London, and the opening ceremony on the 26th October, performed by His Grace the Duke of Devonshire, K.G., President of the Board of Education. The building was constructed of Darley Dale sandstone. The electric lighting and power equipment were installed by the Corporation's Electric Lighting Department. The mechanical and electrical engineering laboratories were equipped by Messrs. Sloan and Lloyd, both former students of the Science Classes.

The *Liverpool Echo,* published on the 23rd October, 1901, included the comment: 'The aspect of the exterior of the building is imposing; that of the interior pleasing and elegant'. Later, in the same report the paper stated: 'The School has nearly 2300 students and a staff of forty-two professors and instructors. Lectures are given and classes held in twenty-two scientific and sixteen technological subjects, and four subjects in applied art'.

The Municipal Technical School was established following a decision of the Liverpool City Council in 1895, authorizing the planning and construction of the school as an extension to the existing Public Museum, Library and Art Gallery. The very attractive building which housed the school was cleaned externally in 1970.

In 1904, a document entitled 'Report on secondary education in Liverpool' by Michael Sadler (Eyre & Spottiswoode), included suggestions and recommendations for the Central Technical School and the Evening Continuation Schools and Technical Classes. The following recommendation was made regarding the Central Technical School: 'The advent of electric lighting and traction, and the great increase in the number of electrical apparatus makers in the city during the decade 1891–1901, viz. from 244 to 1214, should lead in the end to a fairly strong department of electrical engineering, which the present 177 entries form a good nucleus'.

At the commencement of the First World War, the School was taken over and used for recruiting and training for war purposes. During 1918, a Department of Marine Engineering was set up. Six years later additional premises were obtained for courses designed for building apprentices. In 1925, the City of Liverpool Nautical College, which the Corporation had established in 1892, amalgamated with the Technical School. In 1935, the Board of Education approved the proposal that the School should assume the status of a technical college and became the City of Liverpool Technical College. During the Second World War the college organized many courses to assist the war effort.

The growth of technological studies both during and immediately after the war, produced a situation that led to the status of the college being raised in 1949 to that of a College of Technology. In the following year the long established Liverpool School of Pharmacy was taken over and became a department of the College. During the following year the Department of Building & Architecture, which recently had been provided with new accommodation, became a separate institution, and named the Liverpool College of Building.

The demand for places in advanced courses and the growth of research at the College of Technology, made it necessary to transfer much lower level work to the four District Technical Colleges as they became available, at Old Swan, Walton, Riversdale, and the North-East Technical College. Once again, in the 1957-58 Session, the status of the college was improved when the Ministry of Education designated it a Regional College. For some years, commencing in the early sixties, the college became an affiliated Institution of the University of Liverpool, when the School of Pharmacy participated in the course leading to the B.Sc. (Hons.) Pharmacology degree of the university. This association was terminated when the College provided degree courses leading to the degrees awarded by the Council for National Academic Awards.

The original building proved insufficient for the work being done, and additional accommodation had to be provided from time to time in Fontenoy Street, the Royal Liver Building and elsewhere. Following the invention and development of radar, the Department of

Navigation set up a Radar School in premises made available at Gladstone Dock. New buildings were approved but delayed owing to the Second World War, and also for reasons of economy. However, work began in 1956 on the first of three instalments of a new building on a site in Byrom Street, not far distant from the original building. It was first occupied late in 1959 and formally opened in September, 1960, by The Rt. Hon. Sir David Eccles, K.C.V.O., M.P., Minister of Education, who became Lord Eccles. The much larger second instalment was commenced in 1962 and occupied in 1965, first by the Department of Navigation, followed by the Department of Electrical Engineering. Construction of the third instalment, in the form of a tower block, was started in 1969, and some of the accommodation was made available in 1971.

During the last decade of its separate existence the College Departments included: chemistry and biology; electrical and control engineering; food technology (transferred to the Liverpool College of Crafts & Catering in 1965); industrial administration and liberal studies; mechanical, marine and production engineering; navigation; pharmacy; physics and mathematics.

ELECTRICAL ENGINEERING AT COLLEGE OF TECHNOLOGY

During the separate existence of the Liverpool Regional College of Technology from its foundation, as the Municipal Technical School in 1901, to 1970 when it became a constituent member of Liverpool Polytechnic, some thousands of persons engaged in the electrical engineering industry attended courses leading to qualifications in electrical engineering. Classes in the latter subject were available from the commencement, but a department was not formed until 1933. In the 1920s Electrical Installation and similar courses were provided separately from those on technical electricity and telephony, which were the responsibility of the Department of Physics, whose head was Dr. S. S. Richardson, B.Sc., D.Sc., A.R.C.Sc., A.M.I.E.E.

John Cormack, B.Sc., A.R.C.S.T., C.Eng., F.I.E.E., was appointed Senior Lecturer in Electrical Engineering at the Liverpool Central Technical School in September 1931. When Dr. Richardson retired the electrical engineering subjects taught in the Department of Physics became Mr. Cormack's responsibility. The Department of Electrical Engineering was set up in 1933, as mentioned previously, and Mr. Cormack was appointed head, a position he retained until 1939, when he obtained the post of Principal of Bootle Municipal Technical College.

Mr. Cormack was a keen and active supporter of both the Liverpool Engineering Society (he is a Past-President) and the Local Centre of the I.E.E. He was a Committee Member for 19 years and was Chairman during the 1944–45 Session. He was awarded the O.B.E. in 1965.

Mr. J. E. Macfarlane, B.Sc.(Eng.), C.Eng., F.I.E.E., M.I.Mech.E. succeeded Mr. Cormack as Head in 1939 and retired in 1960. For a period, he was Acting Principal of the College of Technology. He served as a Committee Member of the Mersey & North Wales Centre of the I.E.E., and was very active in technical education circles.

Following Mr. Macfarlane's retirement, E. G. Lamb, B.Sc.(Eng.), C.Eng., F.I.E.E., was appointed Head of the Department of Electrical Engineering. He remained at the College until 1965, when he followed Mr. Cormack's example and became Principal of the College of Further Education, Bootle (formerly Bootle Municipal Technical College). He resigned in 1971 to take up the principalship of a college in Scotland. He was a member and served as Chairman of the Education Discussion Circle of the Centre.

E. T. Metcalf, B.Sc.(Eng.), Whitworth Scholar, A.C.G.I., C.Eng., F.I.E.E., was appointed in succession to Mr. Lamb. He resigned in 1971 to take up a position in South America.

Mention should be made of D. Chalmers, A.M.I.E.E.E., M.E.M.E., C.Eng., F.I.E.E., F.I.E.R.E., Senior Assistant Head of Department of Electrical Engineering since 1960, who joined the college in 1945. He served the college devotedly and on a number of occasions assumed the position of Acting Head of Department.

TECHNICAL COLLEGES

In addition to the technical colleges mentioned previously there are a number of others on Merseyside and in North Wales that have made their own contribution to the needs of the community. Space does not permit a detailed review of the work of these colleges, but they include the following: Birkenhead Technical College; Carlett Park Central College of Further Education, Eastham; College of Technology, St. Helens; Colleges of Further Education at Chester, Kirkby, Prescot, Wallasey, Widnes and Runcorn; Denbighshire Technical College, Wrexham; Flintshire College of Technology, Connah's Quay; Llandrillo Technical College, Colwyn Bay; North-East Technical College, Liverpool; Old Swan Technical College, Liverpool; Riversdale Technical College, Liverpool; Southport Technical College; Walton Technical College, Liverpool; Warrington Technical College; and Wigan and District Mining & Technical College.

LIVERPOOL POLYTECHNIC

In 1966 the Government published a White Paper entitled 'A plan for polytechnics and other colleges: Higher education in the further education system'. The Government proposed to designate a limited number of major centres to be known as polytechnics, to concentrate on providing both fulltime and part-time courses of higher education. They would include qualified staff, buildings and equipment to provide a suitable environment. As the plan developed it was proposed that a polytechnic should be established in Liverpool, consisting of the College of Art, the College of Building, the College of Commerce, and the Regional College of Technology.

The Liverpool Polytechnic was formally designated on the 1st April, 1970, bringing together the four colleges mentioned above. At that time some 2000 students were preparing for degrees awarded by the Council for National Academic Awards. The former Regional College of Technology forms part of the Faculty of Engineering.

LIVERPOOL UNIVERSITY COLLEGE

The idea that Merseyside should establish a centre of higher education was topical in the 70s of the last century. The story has been told by Dr. J. Campbell Brown.[24] The setting up of Queens College in 1857 was an earlier attempt to provide the relevant facilities, but it was at a meeting held in 1878, when a deputation met the Mayor of

Liverpool, seeking his help, that commenced the series of events which led ultimately to the founding of Liverpool University College.

A number of sites was considered. Eventually, the Corporation of Liverpool acquired the land and buildings of the old Lunatic Asylum, Brownlow Hill, which became the property of the college. Subsequently, the buildings were adapted to provide accommodation for the new college. The first Council was appointed in April 1881, and Gerald H. Rendall, a classical scholar, became the first principal. A Charter of Incorporation was granted on the 18th October 1881. The first endowment was founded by the Roger Lyon Trust Fund and led to the establishment of the Lyon Jones Chair of Experimental Physics in 1880. The first occupant of the Chair was Prof. Oliver Lodge (Fig. 20) who was appointed in 1881 and remained at Liverpool until he became Principal of the University of Birmingham in 1900. The City of Liverpool made a generous contribution to the endowment fund, which was also supported by other towns on Merseyside.

Oliver (later Sir Oliver) J. Lodge was a leading scientist of his day and made fundamental discoveries in wireless telegraphy. He also contributed to the advance of electrical engineering, particularly during his tenure of the chair at Liverpool. He was born in Staffordshire in 1851. In his autobiography entitled 'Past Years'[25] Oliver Lodge confessed that his schooldays were 'undoubtedly the most miserable part of my life,' but he attended school for only four years and left at the age of twelve to become a private pupil for a further two years. He was introduced to physics through a course of lectures on heat given by Professor John Tyndall, Professor of Natural Philosophy at the Royal Institution, London, to working men at the Museum of Geology in Jermyn Street. These lectures made a great impression on the youthful Lodge.

Oliver Lodge matriculated at the age of 20 and then, having been awarded an Exhibition, graduated in physics at University College, London. He then chose electricity as his subject and passed the D.Sc. examination in 1877. He became a member of staff at UC and remained there until his appointment at Liverpool, where he became responsible for both physics and electrical subjects. One of the tasks that he set himself at University College, Liverpool, was to establish an electrotechnical laboratory, a task he considered outside his range, but at the time required a physicist to handle.

Prof. Lodge delivered lectures on what he described as sensational discoveries in physics, for example, the discovery of Röntgen rays (X rays discovered by Prof. Röntgen in 1895 at Wurzburg), and the discovery of the gas argon by Lord Rayleigh in 1892. He interested himself in electrical storage batteries and became scientific adviser to the Electric Power Storage Co.

In 1896 the British Association for the Advancement of Science met in Liverpool. During a meeting of Section A, Sir William Preece, Engineer in Chief of the Post Office, informed those present of Marconi's discovery of wireless telegraphy. Prof. Lodge was at this meeting, and so also was Lord Kelvin. A young research student from Cambridge also attended his first British Association meeting. His name was Ernest Rutherford.[26] He became Lord Rutherford of Nelson, O.M., F.R.S., and was recognised as the leading experimental scientist of his age. He delivered the 13th Kelvin Lecture before the Institution of Electrical Engineers in 1922, and was awarded the Faraday Medal in 1930. He died in 1937 aged 66.

In 1898 Prof. Lodge was awarded the Royal Society's Rumford Medal. The Lord Mayor of Liverpool (Sir W. Oulton) celebrated the honour given to a distinguished citizen by providing a banquet at the Town Hall. Lodge wrote in his autobiography: ' . . . it was a great event; and I still think it rather remarkable that a city like Liverpool should go out of its way to take note of a purely scientific award made by the Royal Society of London'.[27]

In 1889, Lodge demonstrated his Leyden jar experiments to the Society of Telegraph Engineers (later the Institution of Electrical Engineers) in a lecture entitled 'The discharge of a Leyden jar.' He worked on electrical discharges, and conducted experiments on electric waves travelling along wires. He invented a detector for wireless waves, and patented another device which made selective tuning possible. These matters are mentioned again in later chapters.

In 1905, Lodge was knighted. He retired from the principalship of the University of Birmingham in 1919, and died in 1940. It is interesting to recall that he first became a Member of the Institution of Electrical Engineers in 1889 but resigned in 1894. He rejoined the Institution in 1898, and was elected an Honorary Member in 1924. In 1899 he was awarded a Premium, valued at £10, for his paper on 'Improvements in magnetic space telegraphy.' On the same occasion

G. Marconi was awarded a similar Premium for his paper entitled 'Wireless telegraphy'. When Prof. Lodge left Liverpool in 1900 L. R. Wilberforce was appointed Professor of Physics, and occupied the chair until 1935.

Reverting to the progress of University College, in 1884 it became a member of the Victoria University, Manchester, which permitted students to obtain degrees awarded by that institution, whereas previously they had prepared for those conferred by the University of London. In 1884 the Royal Infirmary Medical School, which originated with the Royal Institution in 1834, and became associated with the Royal Infirmary in 1844, also united with University College.

The growth and success of University College led to a petition applying for a Royal Charter as an independent university. This proposal was approved and the Liverpool University Act 1903 created the University of Liverpool as a separate institution with the necessary powers to conduct its affairs and to award its own degrees.

Principal G. H. Rendall was succeeded by R. (later Sir Richard) Glazebrook during the period 1898–99. He was born in Liverpool in 1854 and educated at Liverpool College, and at Trinity College, Cambridge. Then followed an appointment as University Lecturer in Mathematics and Assistant Director of the Cavendish Laboratory. Following his principalship at University College, Liverpool, Glazebrook became Director of the National Physical Laboratory, and retained this position until 1919. He served as President of the Institution of Electrical Engineers in 1906. He was knighted in 1917 and awarded the K.C.B. in 1920. He was also an F.R.S. and an Hon. M.Inst.C.E. He died in 1935.[28]

Sir Alfred Dale followed Mr. Glazebrook and held the office of Principal from 1899 to 1903, when he became the first Vice-Chancellor of the University of Liverpool. He resigned in 1919.

ELECTRICAL ENGINEERING AT UNIVERSITY OF LIVERPOOL

Even a brief survey of the growth and development of Liverpool University would take up more space than can be made available, so it has been decided to limit the subject to the development of electrical engineering, and to mention some of the persons and activities associated with the Department of Electrical Engineering.

When the new university was established, a Faculty of Engineering was set up. At the same time the financial position permitted the construction of Electrical Engineering Laboratories. The Harrison Chair of Engineering was founded in 1886, and became the Harrison Chair of Mechanical Engineering in 1926. The David Jardine Chair of Electrical Engineering was established in 1903 (in 1946, 'electronics' was added, and in 1952 it became the David Jardine Chair of Electric Power Engineering). Dr. E. W. Marchant was the first occupant of the David Jardine Chair (in 1903) and became responsible for the construction of the new electrical engineering laboratories and their equipment. He had joined the University College two years previously as Lecturer in Electrotechnics. He became a keen participant in the activities both of the Institution of Electrical Engineers, at national and local levels, and of the Liverpool Engineering Society.

Prof. E. W. Marchant was born at Sevenoaks in 1876, and received his education at University School, Hastings, and at the central Technical College, now known as the City & Guilds College, South Kensington. He was an Institution Scholar and a Siemens Medallist. He obtained first-class honours in Physics and honours in Mathematics, when he graduated B.Sc. For a short period he obtained workshop training with Adam Hilger & Co., now part of the Rank Organisation, precision instrument makers. In 1897, he was appointed Superintendent of Lord Blythwood's laboratory at Renfrew. Three years later he accepted the appointment at Liverpool previously mentioned. He has been described as 'a stimulating teacher, always accessible to his students, ever ready to advise on their studies and on their future careers. His personal interest was not confined to the academic progress of each of his students, but he showed the same care for their well-being in their residential life, in their social activities and in their undergraduate societies'.[29]

The Laboratories of Electrotechnics, Brownlow Hill, (see Figs 21 and 22) were officially opened on the 8th July, 1905, by Sir Joseph Swan, D.Sc., F.R.S.[30] Previously the department had been accommodated in temporary sheds erected at the rear of the building in which the work of the University College commenced. Originally, and until about 1900, electrotechnics was regarded as a branch of physics, and

the responsibility of the professor of Physics. A change was made in 1900 when a lectureship in Electrotechnics was established independently of the Professor of physics. Three years later, David Jardine endowed the Chair of Electrical Engineering mentioned earlier. In addition to the laboratories new buildings were constructed comprising classrooms, lecture rooms and elementary laboratories.

During the First World War, the Engineering Department's facilities were utilized for war purposes, and students were not enrolled. The workshops were employed making gauges used for shell production. Prof. Marchant was engaged on work involving the detection of submarines, and with developments in radio. After the war the work in electrical engineering expanded rapidly, owing to the number of ex-servicemen enrolling as undergraduates. This was particularly noticeable from 1922 to 1924. A former army hut was erected in the quadrangle which was converted for use as a machine laboratory, combined drawing office and lecture theatre, and a battery room, to provide additional facilities. This was the only accommodation to be provided for the department following the construction of the original building, until the latter was extended in 1922.

In 1920 the staff consisted of six academics, including the professor, and five technicians. In 1971 the academic staff totalled 33, some 60 technicians were employed, and there were approximately 70 post-graduate research students working in the department.

In 1938 one M.V. impulse generator was installed, and, during the Second World War, it was used for testing gas-filled electric cables. The majority of the staff remained at the university during the war, and, unlike the 1914-18 War, students continued to be enrolled. The department assisted the war effort under the direction of Prof. Marchant (until he retired in 1941) in the fields of aircraft detection by sound locators, and radio direction finding. The engineering laboratories suffered damage following the dropping of a land mine but temporary repairs were soon effected. Additional part-time lecturers from industry were engaged to meet the needs of an increasing number of students.

Prof. J. M. Meek, D.Eng., was appointed to the David Jardine Chair of Electrical Engineering (Electronics) in 1946. In 1952, the title was altered to the David Jardine Chair of Electric Power Engineering. Prof. J. D. Craggs was appointed to the Robert Rankin Chair of

Electronic Engineering in 1955. In 1964, a Chair of Applied Electromagnetism was established, and the first and present holder is Prof. H. Edels.

The increasing demand for facilities in electrical engineering and electronics after the war, coupled with the need for adequate support for rapidly expanding research activities, made it necessary to consider the provision of new premises. Proposals were examined by the building subcommittee in 1959 and new laboratories became available for use six years later.[31] Fig. 23 shows one of the new laboratories incorporating machine consoles and the interconnection board with a shrouded plug and socket, designed by W. W. Kenyon, the Chief Laboratory Technician, who served in the Department of Electrical Engineering for more than 50 years.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

The University of Wales, founded in 1893, is a federation of four university colleges comprising Aberystwyth, opened in 1872 (Royal Charter, 1889); Cardiff, established in 1883 (Royal Charter, 1884); Bangor, set up in 1884 and granted a Royal Charter in the same year; and Swansea, founded under Royal Charter in 1920. In 1932, the Welsh National School of Medicine at Cardiff was recognised as a school of the university. Finally, in 1968–69, the Welsh College of Advanced Technology at Cardiff became incorporated with the university as the Institute of Science & Technology.

The University College of North Wales, Bangor, has had strong links with the Mersey and North Wales Centre of the Institution of Electrical Engineers, through its School of Electronic Engineering Science, with its interest in electronic and control engineering. The school developed from the Department of Electronic Engineering set up by Prof. M. R. Gavin, C.B.E., D.Sc., F.Int.P., C.Eng., F.I.E.E. He served on the Centre Committee and became Vice-Chairman. The electronics course which Prof. Gavin established was of an interdisciplinary nature and included physics and mathematics.

When Prof. Gavin resigned to take up the appointment of Principal of the Chelsea College of Science & Technology, he was succeeded by Prof. R. J. A. Paul, B.Sc.(Eng.), C.Eng., F.R.A.E.S., F.I.E.E., as

Head of the school. At this time, the growth of the school had been such that the other chairs of electrical materials science, physical electronics and systems electronics, had been created. The late Prof. F. J. Hyde, D.Sc., F.Inst.P., M.I.R.E., C.Eng., F.I.E.E., was appointed to the chair of physical electronics. He served as a member of the Centre Committee, and acted as Chairman during the 1967–68 Session.

CHAPTER 3

GROWTH OF ENGINEERING SOCIETIES AND INSTITUTIONS

The establishment and growth of major engineering societies on Merseyside was confined to Liverpool. They emerged when a demand arose from men who wished to meet together to exchange information relating to their professional activities. The two outstanding societies concerned with engineering were the Liverpool Polytechnic Society, and the Liverpool Engineering Society. They were learned societies and did not act as qualifying bodies. Both societies met a need which, in course of time declined, and resulted in their dissolution.

One of the factors affecting local engineering societies has been the formation of local branches or centres, of the national engineering institutions, with headquarters in London. These institutions, and the Institution of Electrical Engineers is typical, combined the activities of a learned society with the self-appointed authority, usually confirmed by a Royal Charter, to act as a qualifying body, because state registration of engineers has not existed.

Local centres developed naturally as the professional engineering institutions grew. Although their main activity was essentially that of a learned body, they were often consulted when applications for membership were received from persons living or employed in their area. These centres also organized social activities on a limited scale. Following the formation of the Council of Engineering Institutions, the Institutions concerned, and their local branches, have continued many of their activities, but some changes have had to be introduced. For example, qualifying examinations are now conducted by the CEI.

No attempt has been made to produce an historical record of either the Liverpool Polytechnic Society or the Liverpool Engineering Society.

The topics dealt with have been considered mainly because of their electrical engineering interest.

LIVERPOOL POLYTECHNIC SOCIETY

The Liverpool Polytechnic Society was established on the 23rd October, 1838, although in a list of Past-Presidents published in 1896, Mr. Henry Booth's name appears as having served as President from 1832–40. This implies that meetings were held before the society was formally set up. The members included a number of leading industrialists and engineers. The first meeting was held in the Medical Institute, Mount Pleasant, with the object of planning future activities. It was resolved:

> 'to recognise improvements in the Manufacturing Arts, such for instance . . . Mechanical Engineering of all kinds.—The Statistics of Improvements in Machinery . . . Inventions connected with the manufacture of works of vertu.—Ornamenting the interior of dwellings. . . Chemical Science applied to the Arts.—Improved Agricultural Implements; with the application of Chemistry and Geology, to Agriculture.—The Cultivation of valuable Timber.—Economy of Fuel.—The application of Heat to Horticultural purposes.—Heating public and private Buildings, and properly ventilating the same.—With other subjects connected with the Commerical interests of this country, and the physical conditions of its inhabitants'.[1]

The second meeting was held on the 2nd January 1839, in the Theatre of the Medical Institution, when an ambitious prospectus was prepared in the following terms:

> 'The object of the Society is to promote the useful and ingenious arts in Liverpool, by securing to their inventors those advantages which, in every department of science, have been found to result from mutual encouragement and co-operation, and from the interchange of ideas in unreserved discussion . . . it will have principally in view the useful mechanical arts, and those ingenious inventions which may be classed in some department of Natural Philosophy, it will not neglect the ornamental arts by which our habitations are embellished, which refine taste and stimulate

ingenuity, and, by a gentle and inobtrusive influence, contribute their part to individual and social happiness'.[2]

The report covering the first two years of the Society's proceedings emphasized that Liverpool had taken a prominent part in the establishment of modern railways and forecast that the Port of Liverpool would shortly become a great centre of steam navigation.

In 1840 there were 177 members. The second President was John Grantham, a leading civil engineer and a strong supporter of the society. Later he went abroad on an assignment, and died in his thirties. At this stage the Society met at the Royal Institution. The business consisted of hearing and discussing papers and communications by members, and examining models and drawings of new inventions, or improvements in the arts.

Included among the papers read during the years 1839 and 1840 were three by Thomas Spencer, a Member of Council, as follows:

12th February 1839: 'On the theory of the formation of metalliferous veins, by galvanic agency in the interior of the earth'

12th September 1839: 'An account of some experiments made to ascertain how far voltaic electricity might be usefully applied to the purpose of working in metal'

14th May 1840: 'On the theory and practice of soldering metals.'

In March 1840, Dr. R. H. Brett, F.L.S., also a Member of Council, read a paper entitled 'On certain views respecting electrical induction.'

The Society's *Transactions*[3] were first published in 1843. In the 'Report of the Council' for that year reference was made to another paper by Mr. Spencer entitled 'On some new Voltaic Arrangements, with Improvements in the Art of Working in most of the metals by the same agency.' A paper entitled 'On Galvanism, applied as an agent in the cure of diseases', was read by G. Ballantyne in March 1849. He considered that the discovery of the use of amalgamated zinc 'as having done more for the advancement of electrical science than any other since its first introduction.' In October 1865 J. T. King exhibited several specimens of submarine telegraph cables; and Capt. W. Rowett, of London, made the suggestion that 'Liverpool, being a maritime port, ought to take the lead in the great subject of laying a cable from England to America'.

Included in an address given by F. Salt, a Vice-President of the Society, in December 1865, were the following comments, typical of the period:

'Half a century ago, the identity of Electric fluid and Lighting was scarcely established. The wonders disclosed by the Galvanic Battery had not even entered into the imagination of man. By a marvellous discovery we have obtained the power to turn the spark of heaven to the uses of speech—to transmit along the slender wire, for hundreds of miles, a current of Electricity that renders intelligible words and thoughts. The sky overhanging our Town is threaded with wires . . . whereby intercourse is carried on between local offices and establishments of manufacture and merchandise. On Land we have overcome the chief difficulties; but in Marine Telegraph much remains to be accomplished. We have laid short lengths of Telegraphic Cable with complete success; but we have failed a second time to unite Europe with America; yet the circumstances of the failure conclusively prove the possibility of ultimate triumph'.

The speaker then mentioned the:

'comparatively trivial circumstances which compelled the *Great Eastern* to return without having done her work'.

Submarine cables were the subject of a paper by J. De La Haye entitled 'Ocean telegraphy' and read by J. T. King, at a meeting held in 1867. The author introduced his theme by reminding his audience 'that the history of ocean telegraphy, although recording some instances of brilliant success, was yet to a great extent a history of failures'. Fig. 24 shows examples of Mr. De La Haye's proposed Atlantic cables (shown as *Figs* 1, 2 and 3 on the original illustration).

Fig. 1 is a side view; *a*, the undulating core; *b*, the first layer of india rubber; *c*, a coating of gutta-percha; *d*, a covering of braided wire; *e*, water-proof varnish; *f*, a coating of gutta-percha; *g*, a second covering of braided wire; *h*, a second coating of varnish; and *i*, another coating of gutta-percha. *Fig.* 2 is a transverse section of a circular cable, and *Fig.* 3 shows a triangular form.

The first successful Atlantic telegraph cable was laid in 1866. It is interesting to compare the cables shown in Fig. 24 with the diagram showing the first Atlantic telephone cable laid in 1956, which can be seen in Fig. 44.

In 1878, the President was G. F. Deacon, the Liverpool Borough and Water Engineer whose address included a section headed 'The Electric Telephone' in which he discussed Graham Bell's invention of the Electric Articulating Telephone, shown in Fig. 25. The President met Prof. Bell immediately upon his return to England after the invention had been perfected in the United States. He showed one of the instruments as it had been developed.

> Fig. 25 shows a section of the instrument. *NS* is a permanent magnet, *B*, an iron diaphragm or disc concentric with the magnet, held firmly by its periphery to the wooden frame *C* of the instrument. Around one pole of the magnet *NS* is wrapped a coil of wire whose section is indicated by the dots. The magnet with its coil of wire constitutes an electromagnet.

Mr. Deacon commented:

> 'Graham Bell's Telephone . . . reproduces, though in a somewhat diluted form, all the three qualities of sound, pitch, intensity and *timbre* and on this account his invention has rendered it possible for the first time to reproduce at a distance all sounds, including that of the human voice'. Later he remarked: 'I recently applied telephones temporarily to a telegraph wire passing from the Municipal Offices through the Aubrey-street Pumping Station and the Kensington Reservoir Station—to the Green-lane Pumping Station—a distance of 4 to 5 miles of wire with three A.B.C. instruments in the circuit—and I found that, notwithstanding a considerable amount of induction, the engineman at Green Lane and a clerk at my office could on the first trial carry on a conversation without difficulty. But the best proof of the manner in which the invention is appreciated where it is known is afforded by the unprecedented rapidity with which the instrument has been adopted in the United States. Last month it appears there were about 6000 instruments at work in America . . . '

The Liverpool Polytechnic Society celebrated its Jubilee in 1887. The following note appeared in the *Journal* at this time: 'Subscriptions are due on the 1st January in advance, and postage stamps will be received in payment from members who may wish to send them'.

During the first meeting of the session held in January, 1887, it was proposed and seconded:

> 'that the Society of Telegraph Engineers be asked to exchange proceedings. There were often very valuable papers read before that Society by some of the most eminent Telegraph Engineers in the country'.

At the conclusion of the session, when the retiring President (J. C. White) addressed the members, he criticised the very scientific and sometimes abstruse character of the papers read before the society, which severely limited discussion. He suggested that papers from the men of the highest scientific attainments would continue to be welcomed, but urged the contribution of papers to encourage 'as much as possible the study and discussion of subjects of any kind of general interest which require technical knowledge for their development'.

At a meeting held in February 1888, Prof. H. S. Hele-Shaw mentioned Mr. Edison's new Phonograph which, instead of employing a sheet of tin foil secured on a cylinder to record the sounds, now used cylinders of wax for receiving the impression of the diaphragm, and gave much better results. In January the following year R. A. Sloan and J. L. Barnes were duly elected members of the Society. The firm of Sloan & Lloyd Barnes was established in 1883, and became one of Liverpool's leading consulting engineers. In 1934, L. C. Grant, a member of the Institution of Electrical Engineers (he was awarded an Institution Premium and gained the John Hopkinson Prize) purchased the firm, and became sole proprietor. Mr. Grant died in 1965 and the practice was taken over by H. Maxwell Rostron, C.Eng., F.I.E.E., of Rostron & Partners, consulting engineers, who for many years was associated with the Liverpool Overhead Railway.

In 1892, F. G. Bailey, B.A., A.M.I.E.E. delivered a lecture on 'Electric traction.' He mentioned the vigorous discussion which was taking place at the time, between the use of storage batteries and the method of obtaining power by means of collecting current from an insulated conductor laid alongside the track.

In 1896, there were some 90 members of the Liverpool Polytechnic Society. The *Transactions* for the LVIII Session were published in the following year, but, by the end of the century the society had ceased to exist.

LIVERPOOL ENGINEERING SOCIETY

A history of the Liverpool Engineering Society (LES) covering the whole 99 years of its existence has not been written. This brief survey considers only its foundation and, in the main, provides details of papers relating to the development of electrical engineering. The society was unique in the area, because it catered for members of all branches of engineering. The growth of the specialized engineering institutions, the difficulty of recruiting young engineers and, to some extent, the impact of the Council of Engineering Institutions, led to the society becoming redundant. In 1876, the year following the foundation of the LES, there were 51 members. At the end of the century the total had risen to 518, and in 1912–13 the figure reached 601. The maximum was reached in 1924–25 when the records show 886 members of all grades. The numbers then declined steadily. In 1969, the membership had dropped to about 250.

For the Golden Jubilee W. E. Mills, F.S.I., who had been a member for 46 years, presented a paper entitled 'Fifty Years of the Liverpool Engineering Society', which was published in 1926.[4] Mr. Mills recalled that the LES was founded in November, 1875, by six pupils of G. F. Lyster, Engineer-in-Chief to the Mersey Docks & Harbour Board, and was named the 'Liverpool Engineering Students' Society', but in November 1876, the word 'Students' was omitted from the title. In the first instance papers were prepared by the members and read weekly, at the home of the author, but, within a year, a room was obtained and visitors were invited to attend meetings. In 1877 arrangements were made for the members to meet at the Royal Institution, where meetings continued to be held until November 1923, when the society procured its own accommodation.

The society's aim was the promotion of the study and practice of engineering. The first President was C. Graham Smith, a much respected and competent civil and municipal engineer, who served from 1875–77. He died in 1884 in his thirties. When the first volume of the *Transactions of the Liverpool Engineering Society* was prepared the plan was adopted of providing a brief notice at least, of every paper read before the society. The preface of the first volume, published in 1881, included the following paragraph:

> 'The Liverpool Engineering Society is still young, but may now be regarded as having survived its infancy, and entered upon a period of healthy and robust manhood. At the time from which its existence dates, there was no society in Liverpool wholly devoted to Engineering interests, and this want, long felt among members of the Profession, was the cause of its being, notwithstanding that its birth was attended with no ceremony, and took place quite unknown to the majority of engineers in the neighbourhood'.[5]

Included in the papers published in the first volume of the *Transactions* was one by E. D. Jones on 'Some of the Advantages of the Metrical System', 'in which the author strongly advocated the adoption of the metrical system. He pointed out the important advantage of the interdependence of the French measures of length, capacity and weight, and showed the labour saved in calculations thereby'.[6] Some 90 years were to elapse before the British Government took positive action in introducing the metric system.

At the 49th meeting of the Society held in December, 1877, the President delivered an address on 'The status and prospects of engineers'. Incidentally, it should be noted that, for many years, Presidents gave a 'Retiring Address' normally in December of each year, and not an inaugural address. Graham Smith complained that leaders of the engineering profession were totally unrecognised by the British Government. He pointed out that notwithstanding the railway mania and the great demand for machinery and engineering works, few men had made large fortunes by engineering pure and simple. He was not happy about salaries. The rank and file of the profession were very poorly paid, considering the amount expended on their technical education and the social position they were expected to occupy. The young engineer could not expect to leave the ranks until he was nearly 30 years of age, and until then he might possibly secure a salary of £300 or £400 per annum. But, on entering the profession, and for no short period of his early life, he could only calculate on earning a few guineas a week. It was only in exceptional circumstances that a man subject to the control of others could expect to make more than £700 or £800 per annum during any portion of his career. Nevertheless he considered that 'An engineer need never be ashamed of poverty, and should be activated by higher motives than mere money getting'.[7]

At the close of his address, Graham Smith was unanimously elected a Life Member, as a mark of appreciation of his labours in connection with the establishment and development of the society.

Anthony G. Lyster read a paper entitled 'Remarks on electric lighting' at a meeting held in November, 1878. He described some of the principal dynamo-electric machines and regulators in use at that time in Britain. In 1881, another paper dealing with the same subject was one entitled 'Application of the electric light at the Free Public Library, Liverpool', which was read by the City Engineer, John S. Brodie.

> The author stressed how the 'use of electricity for purposes of illumination, especially as regards lighting of streets, open spaces, large public buildings and engineer's works, have occupied an important and prominent position before the general public ever since the International Exhibition, held at Paris during the summer of 1878. It was in connection with that Exhibition that its introduction on a large scale was first successfully accomplished, as previous to then the practical use of the electric light had been confined almost entirely to lighthouse purposes'.[8] Mr. Brodie then mentioned that 'the lighting of public streets had been tried on the Thames Embankment and elsewhere, and notably in Blackpool'.[9] Later he said: 'But, so far as the author is informed, it has been left to London and Liverpool, the first and second cities of this great empire, to promote the introduction of the light in illuminating large rooms devoted to the benefit of the general public'.[10] He then described the adoption of electric lighting in 1879 'in the new large reading room connected with the Free Public Library, and named after Sir James A. Picton'.

An 'engine and machine room' was set up in an area adjoining Clayton Street. It contained a twin-cylinder, semiportable type Marshall's patent steam engine, with cylinders 9 in diameter and 14 in stroke, working at 104 rev/min. The engine was fitted with extra-heavy flywheels, and belts were used to drive 'three 'gramme' continuous current dynamo-electric machines of the most recent construction'.[11] Each machine generated current 'sufficient to give an arc with an illuminative capacity equal to 4000 standard sperm candles'.[12] The average speed of the dynamo was some 925 rev/min. Carbon arc lamps were used and the carbons lasted about four and a half hours. It took an attendant from three to seven minutes to change the carbons on the three lamps employed. The cables used were formed of 19 tinned copper strands, each of No. 26 SWG diameter, and gutta percha was employed for insulation purposes. The effect of the introduction of electric lighting gave the room 'a more pure and healthy atmosphere' and 'would have a less injurious effect upon the books and furniture therein'.[13] The new lighting replaced gas lighting which gave cause for many complaints.

Mr. Alfred Holt, M.Inst.C.E., was President in 1881. His retiring address was on the 'Proposed Elevated Railway along the Liverpool Docks'.[14] He contended that there was a need for quick transportation along the line of docks, and referred to the elevated railroad system developed in New York. He said that he had urged the Dock Board to adopt 'a single-line system, with short double portions at the stations for passing places'. He proposed 2-decked vehicles and prophesied that once the Liverpool High Level Railway was in operation 'the wonder will be how we ever got on without it'.

In 1882, J. S. Brodie read a paper on 'Some recent progress in electrical engineering'.[15] He discussed Siemens dynamo-electric generator invented in 1866; the Gramme machine, brought out in Paris in 1868; the Brush dynamo-electric generator, produced in America in 1878; and the dynamo invented by M. Lachauseé, of Liege, which, unlike most others, had a fixed armature with revolving field magnets. Various secondary batteries also were described. The author then discussed the transmission of electrical energy and the use of electric motors. He mentioned that the first practical application of the principle for railway and tramway purposes was made by Siemens Brothers in 1881, in Berlin, and worked entirely by electricity. The electric tramway at the Paris Exhibition held in the same year was also constructed by Siemens. Power was obtained from a vertical engine driving a Siemens d.c. dynamo.

On the 8th November, 1882, Prof. Oliver J. Lodge, D.Sc., F.R.S., was elected an Honorary Member of the society.

In 1883, a paper was read by Mr. A. Bromley Holmes entitled 'Electric light fittings used in the incandescent System'.[16] The subject was topical because of the extension of electric lighting as a source of indoor illumination in premises drawing their supply from a street main. The author dealt with some contemporary electric lamps. The Swan lamp used carbon formed from cotton thread treated with a solution of sulphuric acid which destroyed the fibre and reduced it to a homogeneous condition. Edison lamps used carbons formed from bamboo cane, placed in grooved metal moulds and carbonised in a furnace. Other lamps mentioned were the Maxim, and the Woodhouse and Rawson, which used a holder fitted with three spring sprongs.

The paper on 'Electric lighting from central stations'[17] by W. H. Fleming, read in 1885, emphasised the lack of progress being made in this country, compared with developments in New York City and other American and Canadian cities. In common with the general attitude he severely criticised the Electric Lighting Act 1882, as the result of which investors were disinclined to provide the necessary capital for the construction of central stations in London and other large cities in the United Kingdom. A brief description was given of the installation provided at Colchester in 1884, the first town in England to adopt a system of house-to-house lighting.

The versatility of Engineers of the period was epitomized by Mr. W. E. Mills in his Presidential Address of 1885.[18] He referred to three new factors in the development of modern engineering, namely the introduction of: gas lighting, the electric telegraph and electrical engineering, and hydraulic power. With regard to the development of electrical science and electrical engineering he mentioned the importance of the telephone, electric lighting, and the attempts, 'on the whole unsuccessfully', to apply electricity as a prime mover.

1886 was the year that saw the completion of the Mersey Tunnel Railway, and the start of the construction of the Manchester Ship Canal. It was also a year of high unemployment. In his Retiring Address, the President, C. S. Pain, Assoc.Inst.C.E., dealt almost exclusively with the depression of trade, particularly as it affected engineering, and the various factors concerned. During the same year, Dr. H. S. Hele-Shaw, a lecturer at University College, was appointed to the newly endowed Harrison Chair of Engineering, which in 1926 became the Harrison Chair of Mechanical Engineering. Prof. Hele-Shaw was a member of the society and later served as President.

In 1887, J. C. Vaudrey, Assoc.M.Inst.C.E., presented his paper entitled 'Notes on practical electricity'.[19] The author and A. Bromley Holmes had set up the Liverpool Electric Supply Co. in 1883. Reference to some of the work undertaken by the firm was given in a paper by Mr. Holmes, read at a meeting of the society. He classified the uses to which electricity could be applied under the following heads: medical electricity; electrolysis, or electrometallic depositing, to which could be added electrotyping; telegraphy; telephony; electricity as applied to purposes of illumination; electricity for the transmission of power; electricity as a power for reducing refractory materials, and electrolytic bleaching.

Technical education did not receive much attention at the society's meetings but, in December 1887, the retiring President (John J. Webster) gave an address which included some remarks on the subject:

> He deprecated the notion that 'as regards technical education our country was hopelessly in the rear; and that while the French and German nations have been taking in hand the technical training of their artizans we have neglected ours'.[20] There was he felt 'sufficient evidence to show that we have at our command abundant facilities for imparting technical education to the masses, and that for this purpose we actually spend more money per annum—with the exception perhaps of France—than any other country in the world'. He admitted 'that greater advantages might have been taken; but we must also remember that it is only within comparatively recent years that the *elementary* education of the people has been attended to, and before this was accomplished they were really not in a position to receive or to appreciate the benefits of technical education'.[21]

At a meeting in 1888, the *Transactions* records:

> 'Mr. John Price, Assoc.Inst.C.E., gave an explanation of the aims of the promoters of the 'Architects' and Engineers' Registration Bill'. This gave rise to a discussion upon the professional status of Engineers, that occupied the whole evening'.[22]

In his paper entitled 'Notes on Central Station Electric Lighting'[23] read in January, 1890, C. H. Yeaman, Assoc.Inst.C.E., blamed the Electric Lighting Act 1882.

> 'for the tardy development of the heavy electrical industries and more especially that of the public supply of electricity.' He agreed that the Amendment Act 1889 had eased 'the difficulties which had previously beset the use of electricity in this country (which) had taken the shapes of mad specialisation and legislative restriction. The lessening of these difficulties has removed most of the impediments to the extension of electrical works. That this is the case, is proved by the number of central stations projected and in use all over the Kingdom, in connection with schemes which have sprung into being since the passing of the 1889 Act'.

Mr. Yeamen suggested that the next problem to be overcome was the voltage to be employed. The voltages used ranged through 50, 60 80, 100 and 110 V. The last mentioned voltage was employed at Liverpool at the time. He also stated that little encouragement was given to lay underground mains. Normally, the supply had to be taken through overhead wiring. Details were given of the methods adopted in central station lighting, classified as follows: series system with battery transformers; series-parallel system; three wire system; parallel system with batteries, and the alternating transformer system.

The development of central supply stations was further considered by G. L. Addenbrooke, A.Inst.E.E., at a meeting held in November 1890, when he presented his paper on 'The distribution of Electricity from Central Stations'.[24] He described the principles involved and, in particular, the cost and efficiency of the competing d.c. and a.c. systems. Another informative paper on the subject was that given by Bromley Holmes, M.Inst.C.E., in 1891, entitled 'The Liverpool electric supply stations'.[25] It will be remembered that Mr. Holmes was the senior partner in the Liverpool Electric Supply company when it was founded in January, 1883. The author stated that his object was to describe the central stations in operation under the provisions of the Liverpool Electric Lighting Order 1889. He discussed the history of his company and said that it was not until July 1883 that the first building was installed with incandescent lamps. This was a restaurant in Eberle Street. The current was generated by a gas engine and dynamo located on the premises. The company constructed its first central station in Rose Street, off Lime Street, Liverpool, which commenced to supply current for lighting at the Adelphi and Grand Hotels, and to other consumers. The capacity was less than 1000 lamps. This arrangement continued until 1890 when the mains were connected to a new station. In 1887 a larger station was built in Tithebarn Street and commenced to operate in December of that year. Later, it formed part of the Highfield Street station. In the following year, a station was completed and put into service in Harrington Street. The company established new works, offices, and a central station in Highfield Street in 1889, and the supply from the station was available in October of that year. Another station was constructed in Oldham Place in 1890, and commenced to generate electricity in October.

The figures given below, reproduced from Mr. Holmes' paper, show

how electric lighting developed in Liverpool. The number of 16 candle-power lamps, or their equivalent, connected with the company's stations on the 1st January in each year, were as follows:

Year	*No. of Lamps*
1888	977
1889	3330
1890	6711
1891	11750

In the earlier stations, the engines and dynamos were separate, but eventually each set was combined on one baseplate. Direct current was used at a pressure of 110 V, all the mains being in simple parallel.

In 1892, the rules of the LES were altered to admit Associates, of more than 21 years of age who were not Engineers by profession, but who were qualified 'to concur with engineers in the advancement of professional knowledge'.

During each session the LES organised excursions in the Summer. For example, in 1893 arrangements were made for members to visit the Thirlmere Aqueduct, Penmaenmawr Granite Quarries, Dore and Chinley Railway, the Mersey Aqueduct Tunnel, Norton Water Tower, and the Sunlight Soap Works at Bebington.

The increase in the use of electric lighting gave A. Bromley Holmes another opportunity to inform members of the LES of the developments that had taken place. The title of his paper on this occasion was 'The public supply of electrical energy: its cost and price'.[26] It was presented in 1894. The author first referred to his previous paper dealing with the Liverpool Supply Co's. stations and described the progress made, stating that a new central station had been constructed in Lark Lane, for the residential district of Sefton and Princes Park. In dealing with the cost of production and the selling price of electrical energy, he adopted as the basis of calculation the Board of Trade Unit (equivalent to a current of 10 A at an e.m.f. of 100 V for 1 h). In 1892, the average price obtained by the eight largest supply companies was 6·45 pence per unit. The author considered this figure insufficient on the basis that depreciation and interest were not fully covered. The estimated cost was 9·26 pence per unit, but there were a number of ways in which economies could be effected.*

* One penny equals 1/240 of a pound.

Fig. 26 shows the variation of load of the Liverpool Supply Stations providing electrical energy almost entirely for electric lighting in 1893.

When Prof. H. S. Hele-Shaw, Wh.Sc., M.Inst.C.E., M.I.Mech.E., F.R.Met.Soc., gave his Presidential Address in 1894 on 'Aerial navigation',[27] he discussed navigable balloons and gave details of two experiments conducted in France utilizing electric propulsion. In one case the propelling agency consisted of a dynamo of $1\frac{1}{3}$hp, weighing 120 lb and a battery weighing 400 lb (which could hold a charge for some $2\frac{1}{2}$ hours) driving a screw propeller. On a calm day this balloon could make its way against a light breeze and be steered at will.

At a meeting held in December 1894, Prof. Oliver Lodge contributed a paper entitled 'The second law of thermodynamics', which led to an interesting discussion.

'Some instruments used in measuring and recording electric energy and electricity' was the title of a paper read by W. G. P. Macmuldrow, at a meeting held in February 1896.[28] The lecturer stated that the types of meter used in Liverpool by the Liverpool Electric Supply Co. were those manufactured by Ferranti, and Chamberlain & Hookham, both ampere-hour meters recording directly in Board of Trade Units.

Prof. Lodge presented another paper to the LES in 1898, entitled 'Telegraphy by electric waves across Space'.[29] He mentioned the 'coherer' as a sensitive mode of detecting waves several miles away, and which could work as a telegraph receiver. After commenting on Marconi's ability to provide articles in magazines that appealed to the general public, Prof. Lodge said: 'I do not know if this wireless telegraphy will be of much use as yet; I suppose it will be of some use some time'. He then demonstrated some large-scale apparatus, constructed by his partner, Dr. Muirhead, used for the 'purpose of discriminative communication by means of Hertz waves'. At the time Prof. Lodge was working on a new method which he hoped would send messages big distances, based on magnetism.

John A. Brodie, Wh.Sc., M.Inst.C.E., M.I.Mech.E., was elected President of the LES for the 25th Session, 1898–99. Born in Shropshire in 1858, he served an apprenticeship with the Mersey Docks and Harbour Board. He attended Owens College, the forerunner of Manchester University. His practical experience was obtained at Whitworth's establishment, also in Manchester. In 1881, Mr. Brodie accepted a temporary appointment in the Liverpool City Engineer's department. After two years in Spain engaged on harbour works he again returned to Liverpool Corporation. He then joined J. T. Wood as a partner and engaged in private practice until he was appointed Liverpool City Engineer in 1898. During 1912 he served on a commission of experts appointed to advise the Government of India on the planning and layout of the new capital city of Delhi. When he retired from his post in 1926 he became joint engineer with Basil Mott, for the construction of the first Mersey road tunnel. Mr. Brodie served a second term as President of the LES in 1923–24. In 1931 he was elected an Honorary Member. In 1920 he held the office of President of the Institution of Civil Engineers.

Mr. Brodie acquired a considerable reputation as an engineer. He was intimately concerned with the introduction of the electric tramway system in Liverpool, and he was a great road builder. He was also a pioneer in the field of motor transport. His interest in sport (he gained a County cap for Lancashire as a rugby footballer) led to his invention of the modern goal net for association football. He died at Aigburth, Liverpool, in 1934.

In his Inaugural Address to the Society in 1898, Mr. Brodie described the progress of the various methods of inland transport from and to Liverpool. He touched on the 'very great attention (that) has been given by engineers to the design of motor vehicles' and the application of the oil engine. He suggested that there were 'strong grounds for expecting that properly designed motor-wagons will yet play an important part in the heavy transport trade of Liverpool'.[30]

In February, 1899, Mr. W. H. Preece, C.B., F.R.S., (who was knighted (K.C.B.) later the same year), gave an address on 'Electricity at the General Post Office'. He was the Engineer in Chief at the Post Office. He thought it 'a remarkable fact that the first practical telegraph that was ever laid down was up the Euston Incline on the L. & N.W. Rly.* very shortly after Her Majesty (Queen Victoria) came to the throne.' Mr. Preece had been President of the Society of Telegraph Engineers in 1880, and was President of the Institution of Civil Engineers in 1898–99. He took a leading part in the development of wireless telegraphy and described Marconi's experiments at the meeting of the British Association held in 1896.

It is interesting to recall, in association with Mr. Preece's address,

* London & North-Western Railway Company.

that the General Post Office at Liverpool, in Victoria Street, was opened in the same year. On the 12th July, the *Liverpool Daily Post* reported:

> 'In order to prepare the new office as the telegraphic centre of Liverpool, the engineering staff laid eight miles of new 3-inch underground mains and 128 miles of new lead cable, containing 2477 miles of insulated wires. The working of the telegraphs and telephones will be worked by 250 secondary cells, charged from dynamos.
>
> On the roof of the building is an electric standard, one of the largest and strongest yet built. It is capable of carrying between 600 and 700 wires. It is of steel and weighs 22 tons'.

In 1899, A. Bromley Holmes, M.Inst.C.E., M.I.Mech.E., delivered his Presidential Address and stressed the important place electricity occupied in the routine of daily life, and the services it rendered, for example, to domestic service and in hospitals. He felt that the 'branch of electrical engineering which is attracting the greatest amount of public attention at the present time is probably the application of electricity to mechanical traction, both on railways and tramways'.[31] He also referred to the advantages derived from the introduction of electricity into works and manufacturing industry, and to appliances and results which a few years previously would have been considered impossible. Such things were now accepted as matters of course.

At a meeting held in 1900, Professor Lodge read another paper to the society entitled 'Further progress in space telegraphy'.[33] which dealt in more detail with the general principles formulated at the meeting held two years earlier. He discussed two methods. The first was that adopted by Marconi and the Wireless Telegraph Co.[34] using electrical waves across space, and in his view the most interesting method. The second scheme, one which involved signalling through the earth, which Prof. Lodge had been working on in conjunction with his partner Mr. Davis, made use of what was described as a magnifying telephone, which was accurately tuned to the frequency of the current employed in the transmitter.

In 1903, E. J. Hidden, the District Manager of the National Telephone Company, presented a paper dealing with 'Recent Telephone Developments in Liverpool'.[35] He discussed the telephone system adopted in the city and district served by means of dry-core cables

laid in trenches in the footpath or roadway. At the next meeting of the society H. W. Wilson, A.M.I.E.E., gave his paper on 'Polyphase machinery and working'.[36] He referred to the 'Battle of the systems', between the adoption of either direct current or alternating current as a standard. For many years d.c. had been favoured, but around 1891 2- and 3-phase a.c. plants with synchronous motor equipments began to come into use. In that year, the invention of the a.c. induction motor by Langdon Davies resulted in the first great impetus to polyphase working. The inventors and developers mentioned by Mr. Wilson were Nikola Tesla, Von-Doliro-Dobrowolsky, and C. E. L. Brown.

In Liverpool a.c. plants with d.c. converting equipment for distributing the energy were employed. The author considered that both d.c. and a.c. provided equal services, with advantages on both sides. In Liverpool, the pressure used for high-voltage transmission was 6600 V, 3-phase, 50 Hz. The first 3-phase installation put down in this country, the author stated, was set up in Liverpool some eight or nine years previously, at the North Dock Silos of the Liverpool Grain Storage & Transit Co. The plant was made by the Oerlikon Co. in Switzerland. Mr. Wilson also mentioned that a new 3-phase installation had recently been put down for the Liverpool Corporation Electricity Department, by the British Thomson-Houston Co. The plant consisted of three 800 kW, 3-phase, 50 Hz, 6600 V generators, driven by Willans steam engines, and six induction motor generator substations. The smaller induction motors were used in conjunction with transformers to reduce the voltage on the motors to 220 v.

In 1904 H. S. Meyer read his paper on 'Voltage regulation in alternating current systems',[37] which dealt with varying loads. A week later Prof. E. W. Marchant presented his paper entitled 'Induction motors',[38] commencing with details of the fundamental experiments undertaken by Arago in 1825. In 1886, Nikola Tesla produced induction motors of considerable power, and in the following year Prof. G. Ferraris demonstrated a motor which possessed the basic characteristics. Prof. Marchant went on to deal with the construction, operation, and other factors concerned with induction motors.

Another paper was presented by Prof. Marchant in 1909, entitled 'Wireless telegraphy and telephony',[39] which ranged over a number of topics. He reviewed the progress made with wireless telegraphy, and described some more recent advances, including an account of the possibilities and advantages of this method of signalling. He referred to Prof. Lodge's development of receivers in a system using magnifying telephones accurately tuned to the frequency of the currents applied to the sending end of the system. However, an attempt to signal between England and Ireland in 1895 had not been successful.

Prof. Marchant discussed the discovery of the coherer by Brantz in 1891. The principle of the coherer was based on the fact 'that when electric waves fell on a loose contact such as exists between metal filings in a glass tube, that the conductivity of the filings was greatly increased, apparently by the welding of the filings together'. The author said that this device was subsequently developed by Lodge, Marconi and others, and 'ultimately became a very sensitive and reliable detector of electric radiations'. Marconi used nickel and silver filings in an exhausted tube, and this 'greatly increased both the sensitiveness and the reliability'. With regard to wireless telephony, Prof. Marchant considered it the most recent and important development in wireless signalling. Fig. 27 shows an arrangement of a receiver and transmitter for wireless telephony taken from Prof. Marchant's paper. It operated in the following manner:

> 'The arc serves a source of high frequency oscillations which are transmitted to an aerial, through the high frequency transformer. In the main circuit of the arc is a speaking transformer the primary of which is arranged in circuit with a battery and microphone. When the microphone is spoken to, it causes vibrations on the current going to the arc through the main circuit and thus influences the magnitude and frequency (probably both) of the oscillations which the arc is producing; these variations correspond exactly with the microphone currents. The circuit is accurately tuned to respond to the normal frequency of the emitted oscillations, and the receiver therefore allows current to pass from the battery through the microphone. When the oscillations are altered in magnitude by the microphone current at the transmitting end, the detector fails to conduct current, and the current through the telephone changes and the receiver diaphragm vibrates. If these microphonic currents at the transmitter succeed each other very rapidly, every variation in them is first impressed on the waves emitted from the transmitting aerial, and is thus reproduced on the telephone diaphragm at the receiving end of the system'.

The arrangements shown were those adopted by Ruhmer in his experiments.

According to Prof. Marchant, the total number of wireless stations in 1907 was 1550, including 195 land stations and 170 merchant ships. He reminded his listeners that the first experimental station was erected in 1896, and he felt that 'the progress made is little short of phenomenal'. He was sure that the most important development in the near future would be in Wireless Telephony and prophesied:

> '. . . we may expect before another ten years are over that it will be possible to telephone wirelessly not only to any ship that is crossing the Atlantic, but to any other city within two or three thousand miles of our own'.

'The Growth of public electricity supply' was the subject of a paper read in 1914 by O. Hansom, A.M.I.Mech.E., A.M.I.E.E.[40] The author indicated that the position had now been reached when every town over 20 000 inhabitants, and many smaller towns, included a public supply of electricity. Tramway systems existed in almost every town with more than 100 000 inhabitants. Electric railways were in operation between various centres including Liverpool and Southport, Liverpool and Birkenhead, and there was also the Liverpool Overhead Railway. The total capital invested in electrical undertakings (exclusive of government telegraphs) exceeded £435 millions. 'Yet people still say', said the author, 'that electricity is in its infancy'. Mr. Hanson thought that corporations were in a better position to develop their undertakings rather than companies, 'because with their rates as security there has never been any shortage of capital at reasonable rates of interest wherewith to meet a growing demand'. Companies could not obtain capital 'at anything like such a low rate of interest'. The author also mentioned that turbine generators of approximately 20 000 hp in single units were in use in English power stations. The diesel oil engine had also been introduced into power stations and showed considerable economies, but the price of oil was rising.

Harold Dickenson, M.Inst.C.E., M.I.Mech.E., (M), who succeeded Bromley Holmes as the Liverpool City Electrical Engineer, gave a paper entitled 'Some notes on the Liverpool Electric Supply Undertaking' in 1915.[41] After reviewing the events covering the period 1883 to 1894 (which have been recorded earlier in this chapter) he mentioned the opening of the large station in Paradise Street in 1895, coupled with the closure of the Harrington Street station.

When the Liverpool Corporation took over the undertaking from the Liverpool Electric Supply Co. in 1896, there were four generating stations in use, namely Highfield Street, Paradise Street, Oldham Place and Park Lane, having a total capacity of 4000 kW. Following the transfer of the tramway system to the Corporation in the following year, additional capacity was required, and the Pumpfields station was laid down in 1899, and Lister Drive in 1900. These were much larger than any station previously built in the city. Each station had 12 sets of Willans's engines coupled direct to d.c. generators, each of 700 kW capacity, used in conjunction with Lancashire boilers. In 1903–04, when the second station was constructed at Lister Drive, the first turbines were installed in Liverpool for the public supply of electricity. They each had a capacity of 2000 kW. Water-tube boilers were employed for steam raising. The plant used in the older stations was gradually displaced.

In 1911, turbine sets replaced the Willans and Robinson reciprocating driven sets at Lister Drive No. 1 station, and water-tube boilers were installed. The plant consisted of two 2000 kW turbogenerators, each turbine driving two 1000 kW d.c. generators arranged in tandem, and two 3500 kW and two 6000 kW turbo-alternators were also provided. Six water-tube boilers and economisers replaced the seven Lancashire boilers formerly used.

As the older plant at the Pumpfields station became less used, three rotary convertors of 1500 kW capacity were installed to permit the steam plant to be closed down as required. The energy for the convertors was supplied from the Lister Drive station.

Mr. Dickenson also remarked that 'cooking by electricity is making progress, and so soon as the price of the energy is capable of being reduced a little more, there is no doubt that cooking by electricity will be used very extensively'. The author also felt that although Liverpool as a manufacturing town could not be compared with towns such as Glasgow, Manchester and others, a considerable amount of electrical power was used in the city by manufacturers, because of its convenience.

Prof. E. W. Marchant, D.Sc., M.I.E.E., occupied the Presidential Chair for the 42nd Session, 1915–16, and was installed on 3rd November 1915. His inaugural Address was entitled 'The relation of science to practice in engineering.' and dealt mainly with electrical engineering science and practice.

'Recent developments in telephony' was the title of a paper read by G. C. Marris, B.Sc., (AM), at a meeting of the LES held in 1916.[42] It considered external cabling and wiring plant, and the design of apparatus and equipment provided within exchanges and subscribers' premises. The automatic telephone system was then in course of development, and the author referred to it as 'the most revolutionary change that has taken place'. Nevertheless, he thought it was too early to estimate how far its effects would spread, but its suitability for most purposes was unquestioned. The Automatic Telephone Co. of Liverpool was a leading firm in this development.

The final paper of interest to electrical engineers in this review of the LES is the Presidential Address of Mr. H. Dickenson, M.I.C.E., M.I.Mech.E., M.I.E.E., entitled 'Electricity supply', and delivered in 1917. Two years later the Liverpool Sub-Centre of the North-Western Centre of the Institution of Electrical Engineers was formed and, as a result, professional electrical engineers on Merseyside were able to organize their own meetings and social events. However, the Liverpool Engineering Society continued to include, in its membership, members of the Institution of Electrical Engineers. In November 1923, the society held its first meeting in its new rooms, 9 The Temple, Dale Street, Liverpool. This brought to an end the society's long association with the Royal Institution. The LES continued to thrive for many years, but in the late 1950s and early 1960s difficulties arose, particularly in connection with finances. Membership began to fall and economies were applied. The society's fortunes varied from year to year, but the financial position continued to deteriorate and membership continued to decline. In 1969 there appeared to be no positive answer to the problem of the society's future existence. Following a resolution of the members the Society ceased to exist at the end of 1970, having survived 95 years.

COUNCIL OF ENGINEERING INSTITUTIONS AND THE MERSEY & NORTH WALES COMMITTEE

The Engineering Institutions Joint Council (EIJC) was founded in 1962, to enable the professional engineering institutions to meet together, and to formulate common policies when possible and desirable, so that the Council's views would represent the profession as a whole. The EIJC was replaced by the Council of Engineering Institutions (CEI) in 1965. The Council represents some 250 000 chartered engineers, who are members of the fifteen constituent institutions forming the Council in 1973. It aims 'to unify and enhance the profession of engineering and to present a common front to the Government and public'. An examination system has been established covering the various branches of engineering to provide a uniform standard of academic competence.

In 1971, amendments to the CEI Charter and Bylaws gave the Council authority to set up the Engineers Registration Board, and to establish a Composite Register for the engineering community, comprising Chartered Engineers, Technician Engineers, and Engineering Technicians.

At the present time the following chartered engineering institutions constitute the Council:

> The Royal Aeronautical Society; The Institutions of Chemical Engineers, Civil Engineers, Electrical Engineers, Electronic & Radio Engineers, Gas Engineers, Mechanical Engineers, Mining Engineers, Mining and Metallurgy, Municipal Engineers, Production Engineers, and Structural Engineers; The Institutes of Fuel, Marine Engineers; and The Royal Institution of Naval Architects.

Local Committees of the Council of Engineering Institutions have been set up to support the Council's work. The events leading to the formation of the Mersey and North Wales Committee followed discussions which took place informally in 1966. As a result proposals were put forward jointly by nine constituent institutions, who either had Centres or Branches in the area. However, at the meeting of the IEE Centre Committee held on the 4th April 1966, the Chairman, D. M. MacLaren, advised the members that the CEI would prefer that the proposal for the formation of a local committee based on Liverpool should be sponsored by one or at most two of the Parent Institutions, and not all nine. It was agreed that Prof. J. B. B. Owen of the Institution of Civil Engineers should be consulted and informed that the Institution of Electrical Engineers would be prepared to sponsor the proposal.

At the Committee meeting held at the Exchange Hotel on the 14th July 1966, the Honorary Secretary reported that he had received the approval of the constituent members of the CEI in the Merseyside area, for the IEE to sponsor the formation of the proposed CEI Committee.

A meeting of the constituent members of the CEI in Merseyside was held on the 26th September 1966, when representatives of the Institutions, which had now risen to ten, formulated the proposed Rules of Conduct for the Committee, using as a basis the Model Rules of the CEI. These proposals were then sent to the Secretary of the Institution of Electrical Engineers with a request that he should again approach the Council of the CEI regarding the setting up of the committee. Following the approval of the proposals the first meeting of the CEI Local Committee took place on the 27th June 1967, when Prof. J. B. B. Owen was elected Chairman. At a later meeting, B. F. Tickle agreed to serve in the joint capacity of Honorary Secretary and Honorary Treasurer. In due course he was succeeded as Honorary Secretary by Mr. E. Walshaw, who continued in office during 1972–73. The Chairmen who succeeded Professor Owen were J. Winskell, R. Dunshae, E. Levison, and S. Towill, a Fellow of the Institution of Electrical Engineers, and a former Centre Chairman, who was in office during 1971–73.

The CEI Committee set up the Mersey and North Wales Education & Training Sub-Committee to undertake various functions in the field of engineering education and training. When the Sub-Committee was reconstituted in 1972, J. Caird, a Fellow of the Institution of Electrical Engineers, and a recognised specialist in education and training matters, was elected Chairman.