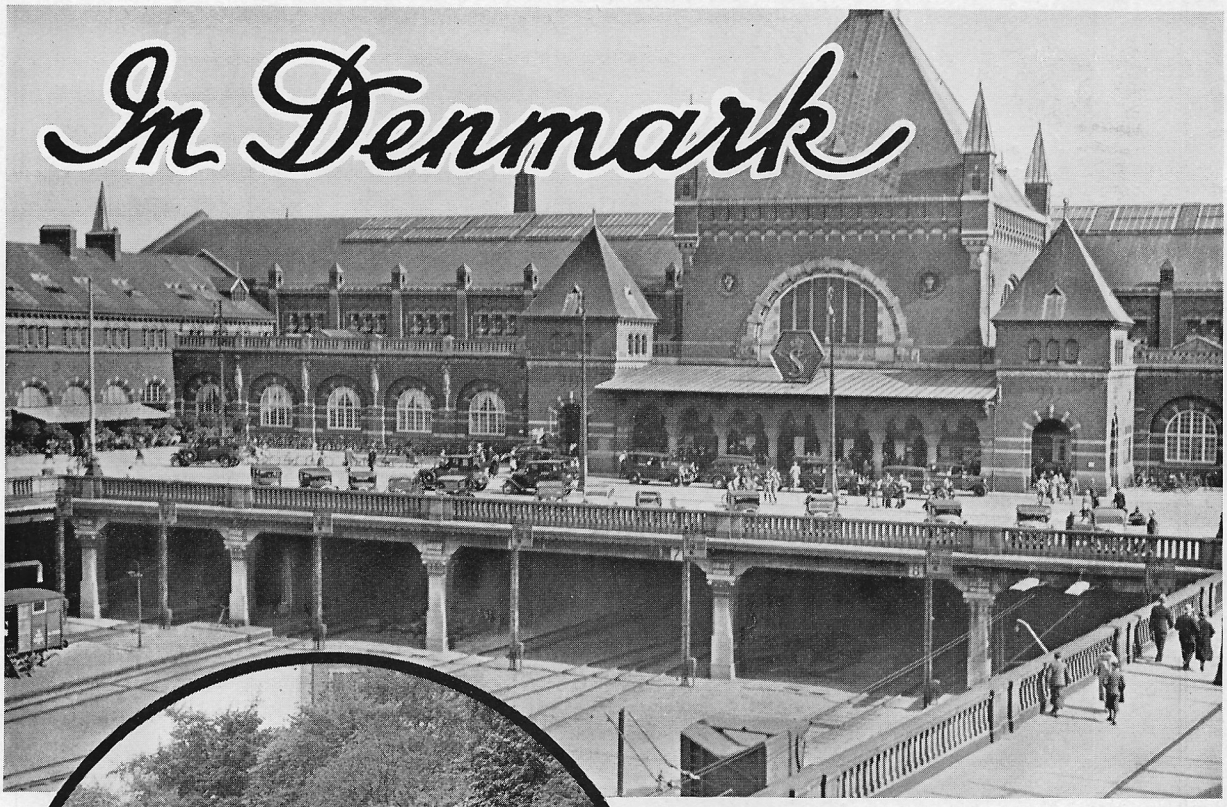
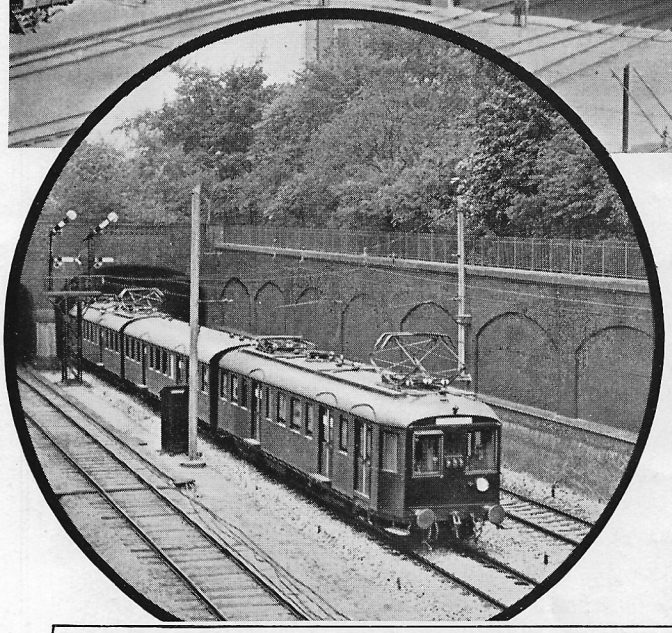
RAILWAY ELECTRIFICATION SERIES . . . . . No. 59

In Denmark





COPENHAGEN SUBURBAN LINES

ELECTRIC TRACTION EQUIPMENT
for
Sixty-two Motor Coaches and Thirty-one Trailer Coaches
was supplied by
THE ENGLISH ELECTRIC COMPANY

The ENGLISH ELECTRIC Company Limited

REGISTERED OFFICE: QUEEN'S HOUSE, KINGSWAY, LONDON, W.C.2.
103415C PRINTED IN ENGLAND. Publication No. R10.

Departure Platforms of Copenhagen Central Station.

Electric Train en route for Klampenborg.

DANISH STATE RAILWAYS

COPENHAGEN SUBURBAN LINES

COPENHAGEN, with its 750,000 inhabitants comprises quite a large proportion of the total population of Denmark, and the area around the city is by far the most densely populated part of the country.

Diesel traction has already been used to a considerable extent in Denmark for main line and branch line service, but the heavy traffic loading of the suburban lines of Copenhagen provided a very suitable subject for electrification, it was therefore decided to electrify in the first instance the system as shown in Figure 1. The present stage comprises about 40 kilometres, but this will be considerably extended later.

The original Copenhagen Suburban service had been run by steam trains, but these had proved inadequate to meet the growing traffic demands, and it was anticipated that with the faster and more frequent service provided by electric trains the passenger traffic would increase still more rapidly. This actually proved to be the case.

The original order for the complete electric traction equipment for 42 motor coaches and 21 trailer coaches was placed in July, 1932, with the English Electric Co., Ltd., in collaboration with their Agents, Messrs. Sophus Berendsen Ltd., of Copenhagen. The rolling stock was made in Denmark at the Works of Aktieselskabet Frichs, and Vognfabrikken Scandia.

A comprehensive inspection and test of the first two motor coach equipments operating under power was carried out at the Bradford Works of the Company from February 27th to March 1st, 1933, by the Chief Electrical Engineer of the Danish State Railways, and at the successful conclusion of these tests the first two motor coach equipments were shipped on the 10th March.

The first trial runs on 1,500 volts were carried out on the section of line Vanlose to Hellerup on November 19th, 1933, in the presence of all senior officials of the Danish State Railways, and were completely successful. The run from Vanlose to Hellerup, a distance of 8 kilometres, was carried out in 10 minutes including stops, against an anticipated time of 12 minutes.

The official opening ceremony for the inauguration of the public service took place on April 3rd, 1934. After the electric service had been operating for three months, the English Electric Co. received a repeat order for the electrical control equipment of 20 motor coaches and 10 trailer coaches, the traction motors being made in Denmark to "English Electric" Design and Specifications.

The first part of the electrification which was running in 1934 comprised the circular line Copenhagen—Hellerup—Vanlose and the line Hellerup—Klampenborg. The extension which will be opened in 1935 will be from Hellerup to Holte and will complete the first stage of the suburban electric system.

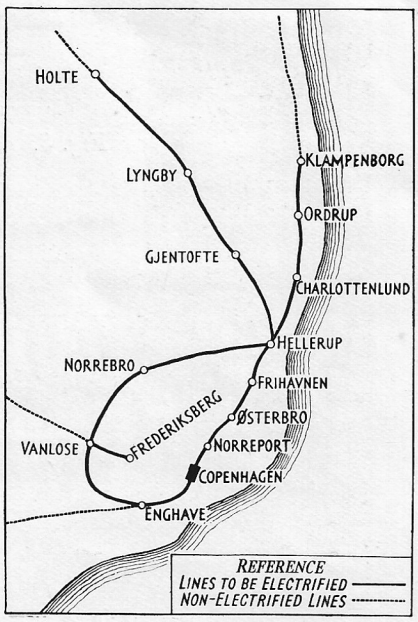


Fig. 1. Sketch map of Copenhagen suburban railway system.

All-Electric Camshaft-Type Control Equipment.

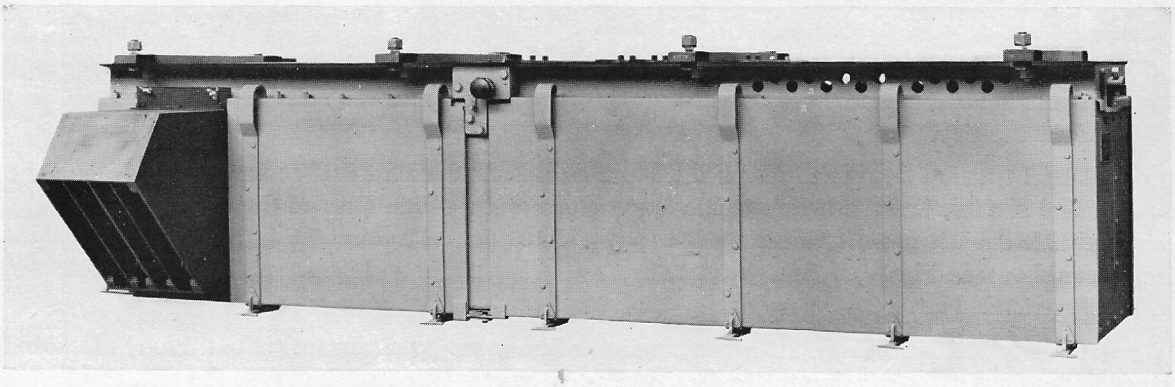


Fig. 2. Front View of Main Control Gear with Covers in position.

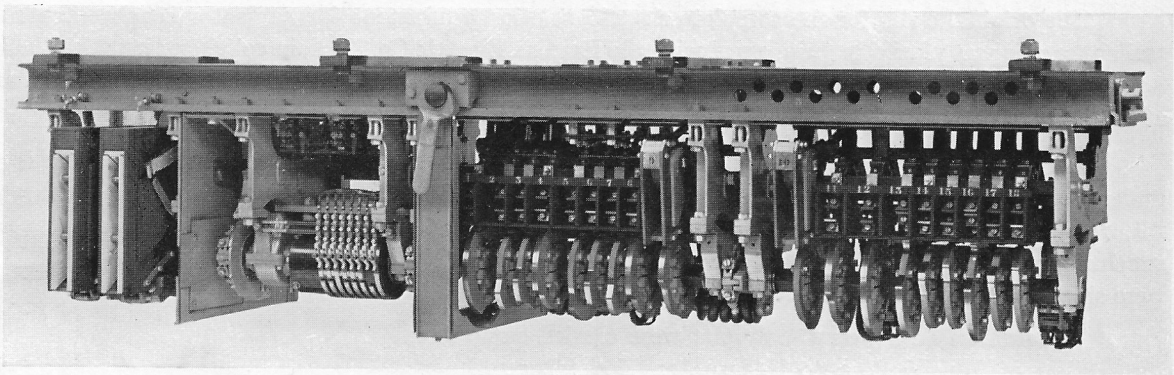


Fig. 3. Main Control Gear with Covers removed.

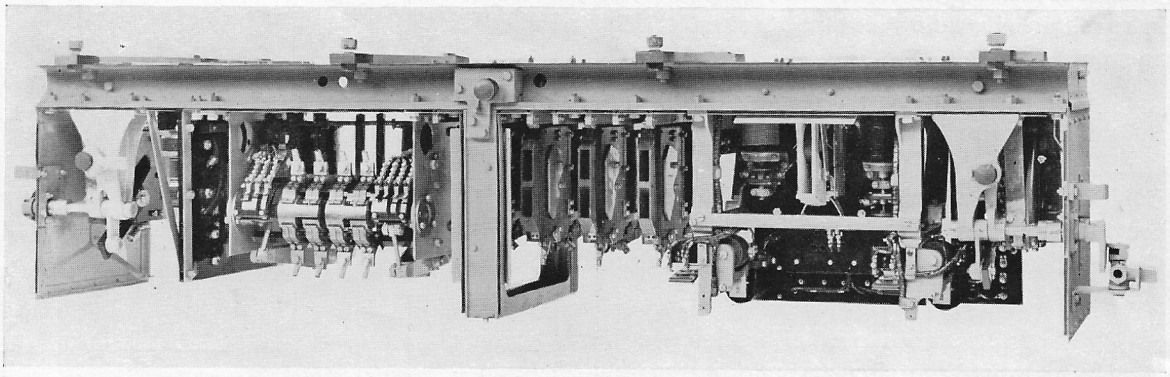


Fig. 4. Auxiliary Control Gear with Covers removed.

The control equipment is of the " All Electric Camshaft " type, which is operating successfully on suburban systems in Madras, Bombay, Capetown, Vancouver, Japan, and in many other parts of the world. The bulk of the control gear is contained in two cases carried on the motor coach underframe. Fig. 2 shows the main control gear with covers in position, and Figs. 3 and 4 show the main and auxiliary control gear with the covers removed. The cases are made specially with dustproof joints to ensure that all dust and snow is excluded. In Denmark, dry snow, of a fine powdery nature, is often experienced; as this has particularly penetrating properties great care has been exercised in the designs to make full provision against this.

The covers of both gears are interlocked with the 1,500-volt main isolating switch and also with the pantograph air supply, so that the pantographs must be lowered and the main isolating switches opened before the covers can be removed; thus making all high tension apparatus in the cases quite " dead " and safe to work on.

Two air-operated pantographs are fitted on each motor coach for collecting current from the overhead line. These pantographs have a system of balanced springs which give close regulation of pressure on the overhead line over the full range of operation. Fig. 5 shows a typical pressure regulation curve of a pantograph.

The main H.T. circuits are protected by an " English Electric " enclosed type cartridge fuse, which is capable of clearing short circuits on 1,500 volts. When power is shut off during driving, the main circuits are normally opened by a pair of quick-opening cam-operated line circuit breakers; and a pair of overload relays, one in each main motor circuit, trip these line-breakers in case of overload.

The design of the cam-operated line-breakers is of unusual interest and is illustrated in Fig. 6. The construction and operation are as follow :—

Two solid cut cams of specially durable material, which are mounted on an insulated square shaft and driven from the main contactor camshaft, close the contacts against powerful springs. These springs give a very quick break on opening, and, in conjunction with the metallic shield blow-out, enable the line-breakers to clear currents due to the heaviest overloads.

The operating mechanism consists of two cam rockers, which are pivoted in the middle and carry at one end a roller; at the other they are connected to the lower extremity of two toggle links. There are two L.T. operating coils, which, when energised, lift clappers which hold the toggle joints straight and enable the main contacts to be closed by the action of the cams. When the operating coil circuit is broken the toggle joints collapse, causing the main contacts to open immediately, irrespective of the position of the camshaft. The clappers also actuate auxiliary L.T. contacts, which set the camshaft motor in the right direction for returning the camshaft to the " off " position immediately the line-breakers are open.

The control circuits and coach lighting are supplied with current at 65 volts from a 1.8 kW. 1,500/65-volts motor generator set fitted with voltage regulator. The set is mounted on the motor coach underframe, and all generators throughout a train are connected in parallel on to a common L.T. bus-line running through all coaches. The motor generator sets are self-ventilated and draw air through ventilating ducts in the

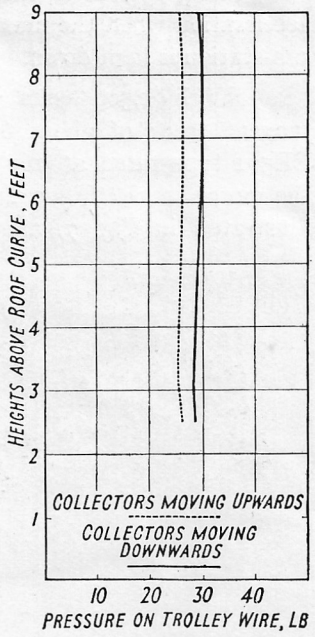


Fig. 5. Pantograph pressure curve.

coach body to ensure clean operating conditions for the inside of the sets. In the event of failure of the power supply, and consequently the 65-volt supply, an automatic relay switches in the emergency lights which are supplied from a 24-volt battery.

The main starting resistance is of the "unbreakable" type, two banks of special alloy strip metal being supported in steel frames and mounted on the motor coach underframe. Double insulation of the live elements is provided; the primary insulation is of mica and the secondary of porcelain, to ensure an ample factor of safety.

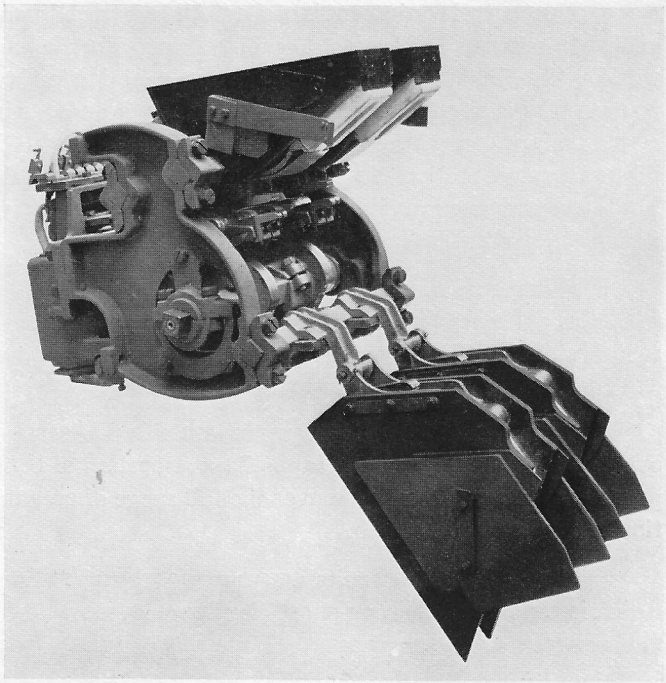


Fig. 6. Cam-operated Line-breaker.

Each coach is heated electrically by 12 series-connected units operating on the 1,500-volt circuit. The heating is controlled in stages of one-third, two-thirds and full heat by means of a remote control switch in the driver's cab controlling 1,500-volt contactors in the heater circuit. Each motor coach also supplies heat to half the trailer coach next to it, through semi-permanent heater connection boxes and a jumper cable between the coaches. An interesting feature of the heating system is that a current limit relay cuts the heaters out of circuit during periods of acceleration when the maximum current peaks occur; consequently, the current peak load on the sub-station is kept down.

With 1,500 volts on the overhead line, the trains attain a balancing speed on level tangent track of about 62 miles per hour. The traction motors are of the "English Electric" EE501 type rated at 160 H.P., 750 volts. Two motors are fitted in the bogie at each end of the motor coach, thus making a total of 2,560 H.P. for a 6-coach train of 306 tons. The motors, illustrated in Fig. 7, are self-ventilated, and, like the motor generator, draw their ventilating air through ducts in the coach body to assist in keeping the interior of the motors clean. This system has been used satisfactorily and found highly efficient on the Madras Suburban Electrification of the South India Railway.

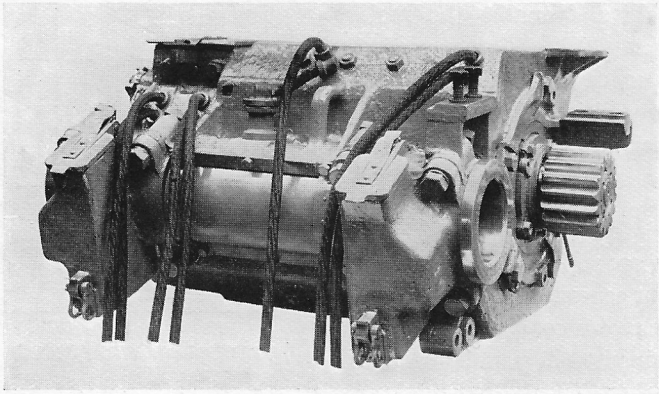


Fig. 7. "English Electric" 160 H.P. Traction Motor.

The control gear is arranged to give six resistance notches and one field tap notch of 74 per cent., with series grouping of the motors, and five resistance notches followed by two field tap notches of 74 per cent. and 56 per cent. with parallel grouping of the motors. Normal series parallel grouping of the four traction motors is

provided, the motors being arranged in pairs in permanent series. The notching is entirely automatic and controlled by a cam-operated current limit relay fitted on the main control camshaft.

The Danish State Railway specified very careful regulation of the accelerating currents, and this has been made with a view to limiting the peak current demand whilst ensuring good acceleration. In series the notching-up value is 200 amps., and the average value 230 amps. per motor coach; in parallel this is reduced to 130 and 150 amps. respectively per pair of motors, i.e., 260 and 300 amps. per motor coach. Fig. 8 shows the main starting diagram.

In addition to the above, reduced acceleration for bad rail conditions is also obtained by means of a tapping on the shunt current limit relay coil. This is controlled by the driver from a push-button switch in the cab.

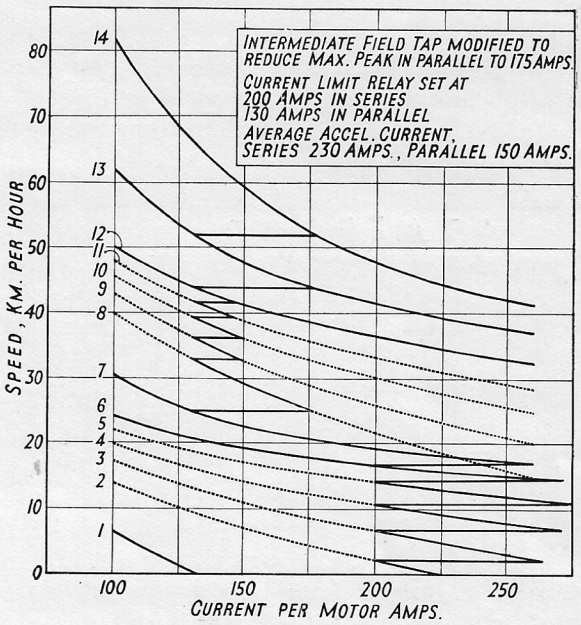


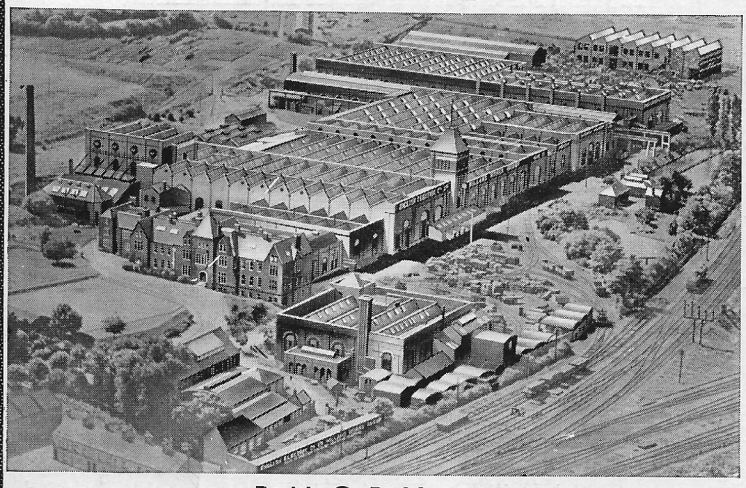
Fig. 8. Main Starting Diagram.

Four notching positions are given on the master controller :—(1) First series for shunting only. (2) Full series, intermediate field tap of 74 per cent. (3) Full parallel. (4) Full parallel, field tap 56 per cent. By this means a very flexible driving control is provided.

Fig. 9. Train on the elevated track on Vanlose—Hellerup section.

THE ENGLISH ELECTRIC COMPANY LIMITED

STAFFORD



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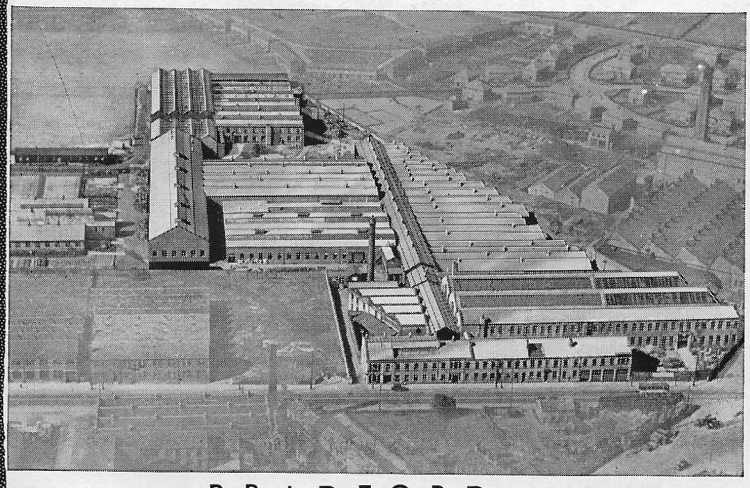

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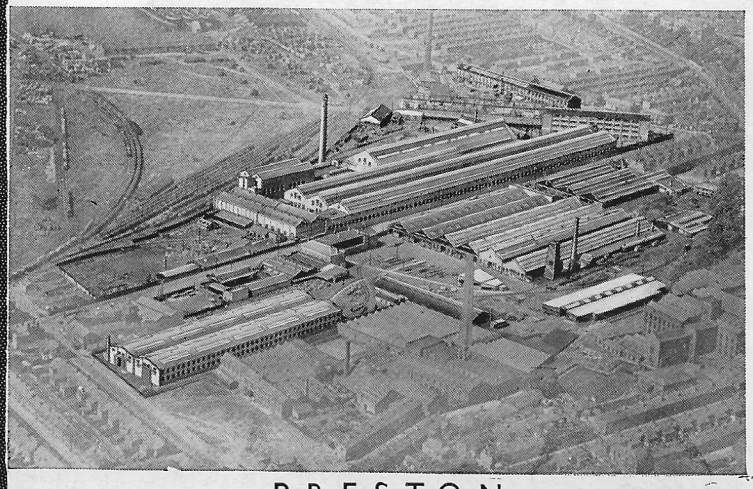

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