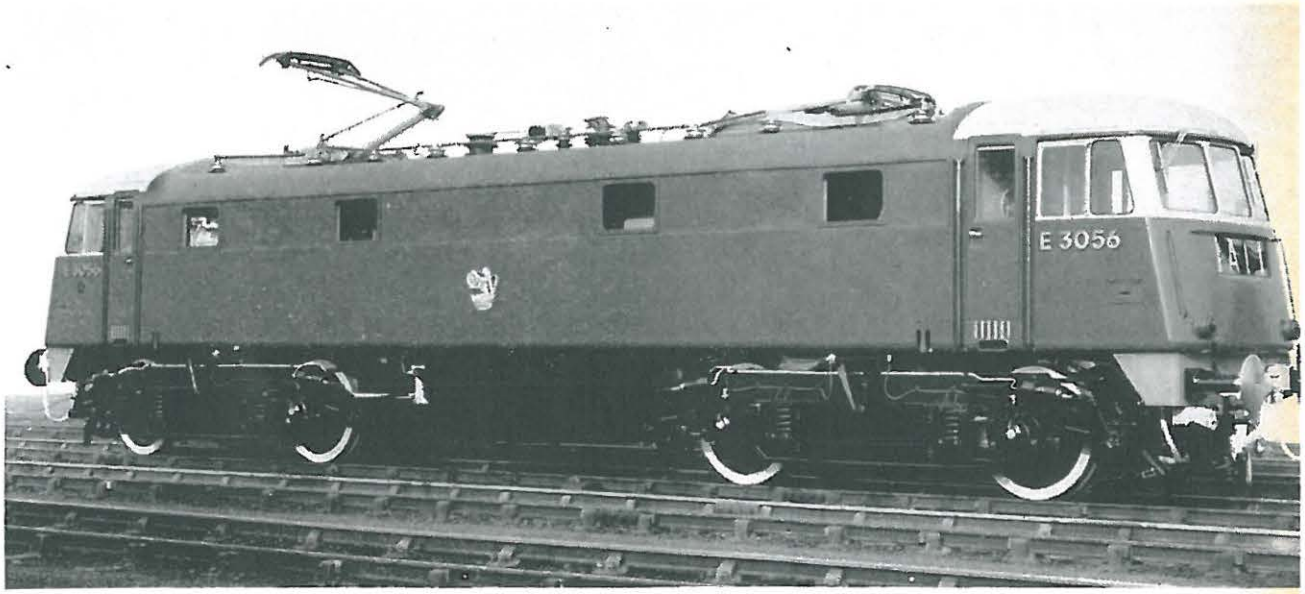
1737-74

Associated Electrical Industries Ltd
TRACTION DIVISION

HIGH-VOLTAGE A.C. LOCOMOTIVES BUILT BY BRITISH RAILWAYS

Type A units incorporating semi-conductor rectifiers and rheostatic braking for the London Midland Region



British Railways Type "A" a.c. electric locomotive

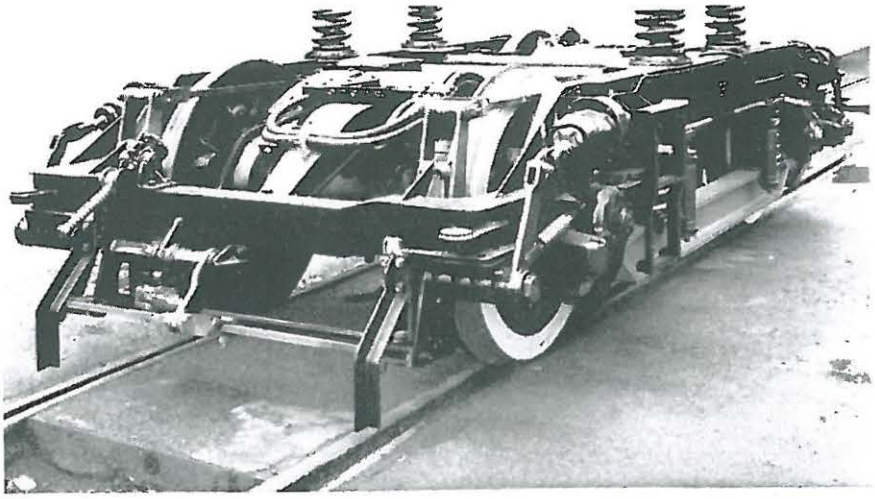
Deliveries are now taking place from British Railways workshops, Doncaster, of forty 25-kV/6·25-kV, 50-cycle a.c. electric locomotives for operation on the London Midland Region. The serial numbers allocated to this order are E3056-E3095 inclusive. Designed at Doncaster to the requirements of the Chief Electrical and the Chief Mechanical Engineers of the British Transport Commission, this locomotive incorporates AEI electrical equipment. This equipment is generally similar to that fitted in the AEI (Rugby) E3001/23 locomotives except that semi-conductor rectifiers and rheostatic braking are used. On thirty of the equipments (E3056 to E3085) the rectifiers are germanium, with silicon on the remaining ten. It is expected that the use of the rheostatic brake will effect a considerable reduction in brake gear maintenance and in wheel wear. The power compartment body has been designed to provide maximum access to equipment during maintenance.

Reprinted (with modifications) from an article appearing in the "Railway Gazette" January 13th, 1961.

LEADING CHARACTERISTICS

(Performance figures are based on a supply voltage of 22.5 kV or 5.63 kV).

Wheel arrangement		Bo-Bo
Maximum service speed		100 m.p.h.
Weight in working order		80 tons
Maximum axle load		20 tons
Continuous ratings—	Full field	Weak field
Tractive effort—lb.	20,000	17,000
Speed—m.p.h.	60	71
Horse power	3,220	3,220
Max. T.E. at 26 per cent adhesion		48,000 lb.
Weight of electrical equipment including drive		39.6 tons
Weight of two bogies (excluding motors and drive)		20.6 tons
Weight of underframe and body		19 tons
		ft. in.
Length over buffers		56 6
Height over cab		12 4¼
Overall width		8 8½
Bogie wheelbase		10 9
Bogie pivot centres		31 6
Wheel diameter		4 0
Gear ratio		29/76



Alsthom type bogie, showing brake cylinder mounting and spring loaded side bearers

EQUIPMENT LAYOUT

The main equipment is installed in two totally-enclosed compartments, one of which contains the rectifier and rectifier cooling fans. The corridor adjacent to the rectifier unit is of sufficient width to withdraw the cell trays for servicing. In the central compartment are the main transformer and oil cooling equipment, tap changer, motor contactor frame, braking resistors, and train heating panel. The transformer cooling fans and radiators are mounted above the transformer. The access doors to this compartment are fully interlocked with the pantograph raising and roof earthing gear.

Between the rectifier compartment and the cab rear bulkhead at No. 1 end are the brake compressor and the main air reservoir, one traction motor blower, A.W.S. equipment, and the fault indication panel. In the compartment behind No. 2 cab are the two brake exhausters, an auxiliary battery-driven compressor, one traction motor blower, battery charging equipment, and a chemical toilet. Equipment underslung between the two bogies includes the smoothing chokes, battery box, field shunt, divert resistor, auxiliary equipment rectifier, and the brake reservoirs.

Current collection and conversion

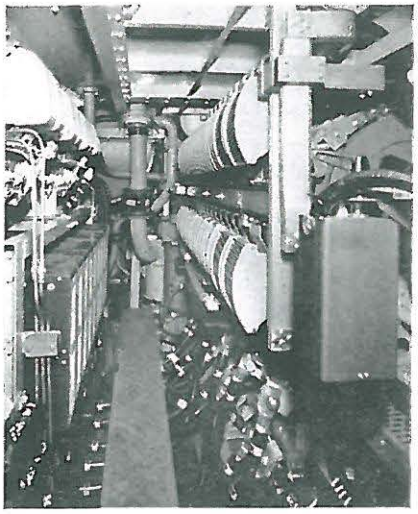
Mounted on the power compartment roof are two Stone-Faively pantographs, the Brown Boveri air-blast circuit breaker, and the potential measuring unit associated with the operation of the 25-kV/6.25-kV changeover switch. Control of the air-operated switch is by relay-operated magnet valves.

The oil-cooled transformer and change-over switch are mounted in a steel tank which is carried on the underframe on resilient trunnion mountings. The primary winding is in four sections which may be connected in series or parallel to suit the line voltage. Oil cooling is by pump circulation through two Serck radiators mounted in the power compartment roof. The cooling air is ducted from the body-side to two horizontal blowers which discharge upwards through the radiators. Louvered aluminium covers are fitted over the roof outlets.

Germanium and silicon rectifiers

The semiconductor rectifier is built up with strings of cells mounted in vertical trays. On the germanium type there are 20 trays, each containing 64 cells, and on the silicon type 12 trays of 28 cells. Individual trays are arranged to slide out of the frame into the corridor for inspection and maintenance. The cells are in series and the strings connected in parallel groups to form the arms of a bridge circuit. Each tray is protected by four fuses and the locomotive can continue to operate on a full power with one string of cells cut out. Cooling is by two vertical axial flow blowers, drawing air through the bodyside, down through the blowers and upwards through the rectifier frame. The cooling air is discharged through louvered roof traps. The d.c. smoothing chokes mounted below the underframe are naturally air-cooled. The external cylindrical core and the coils, wound on flat strip, are enclosed in a glass-fibre casing.

The control gear and tap changer are mounted together on a steel frame. Operation of the



Tap changer and motor contactors in h.t. compartment

Rectifier tray withdrawn for inspection

contactors is by moulded cams on a steel camshaft. The camshaft is driven, through reduction gearing and a geneva stop mechanism, by a d.c. motor on which dynamic braking is used. De-ion arc chutes are fitted to the contactors.

Traction motors

The four traction motors are six-pole series-wound d.c. machines with class "H" insulation. To eliminate the effect of the a.c. ripple of the 50-cycle supply the poles are interconnected with a shallow laminated ring. Each motor has a continuous rating of 975V, 700A, 847 s.hp, and a 1 hr. rating of 975V, 760A, 920 s.hp. The motors are fully suspended on three-point rubber mountings; two at the nose and one on an extension arm at the rear. The motors are fully interchangeable with those of the AEI (Rugby (Limited—Birmingham Railway Carriage & Wagon Co. Ltd. locomotives.

From the reduction gearing, which has a ratio of 29 : 76, the drive on the Alsthom system is taken through a quill shaft to a universal link assembly, which in turn drives the wheels. The quill shaft is carried in the motor frame in large diameter taper roller bearings. Rubber bushed pivots are used throughout the linkage to eliminate lubrication.

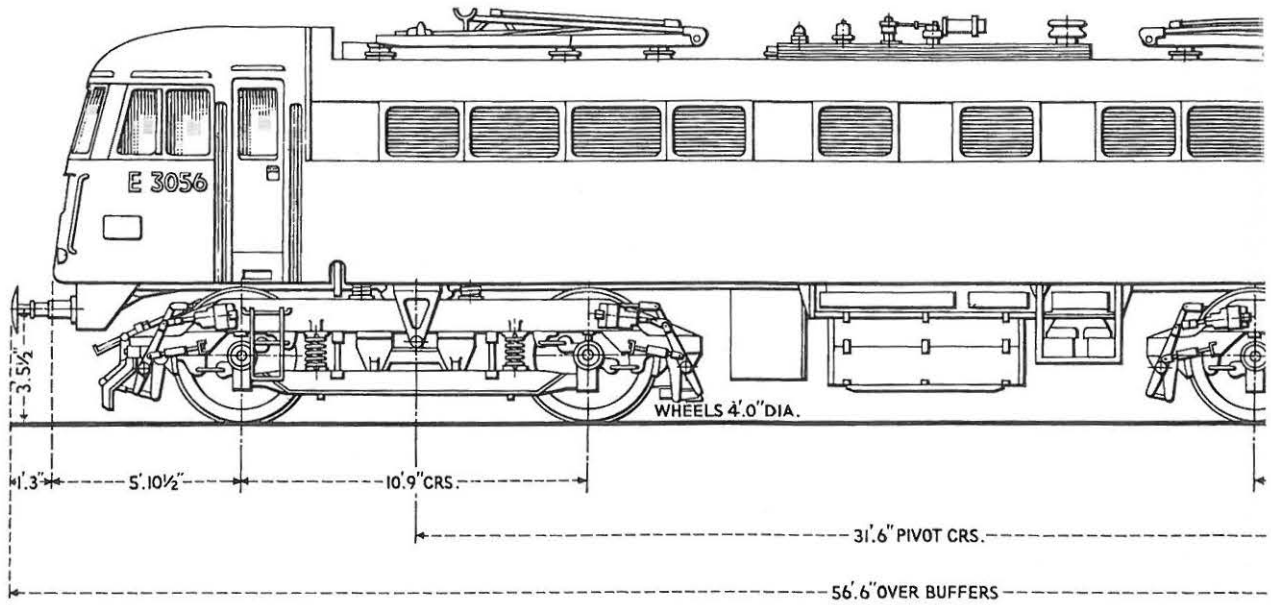
One pedestal-mounted blower is fitted for the two traction motors of each bogie. Air is drawn through glass-fibre ducting from louvers in the bodyside. Glass-fibre ducting, built into the underframe is also used to distribute the air to the motors.

The driving cab at each end is of double-skin construction, with steel sheets on the outside carried on a steel frame. The roof is lined with a glass-fibre moulding and the sides with plastic-faced plywood panels. Sprayed asbestos is applied inside the cavity for heat and sound insulation. Up to window level the cab sides are an integral part of the main frame structure. Flanged plates are used for the cab front to provide maximum stiffness. Double-glazed armour-plate glass is used for the front screens. Pneumatic screen wipers and electric demisters are fitted on the two large screens.

Driving controls on the plastic-covered desk are arranged in the B.R. standard form used on all a.c. electric locomotives. The master controller, for operating the tap changer, and the reverser with positions for forward, off, and reverse, are on the driver's right and the vacuum and straight air brake controls on the left.

Flush-mounted on the sloping instrument panel fitted below the driving window are the air pressure and vacuum gauges, speedometer, ammeters, light switches and indicator lamps. Coloured sectors are used on the ammeter scales for driver guidance during acceleration and running. The cab is well heated by a number of electric heaters and a full height draught screen is fitted behind each of the fully upholstered adjustable seats. Access to the power compartment is by a central door in the cab rear bulkhead.

In this design the requirements of minimum weight and a rigid structure have been obtained by combining the lower halves of the bodysides



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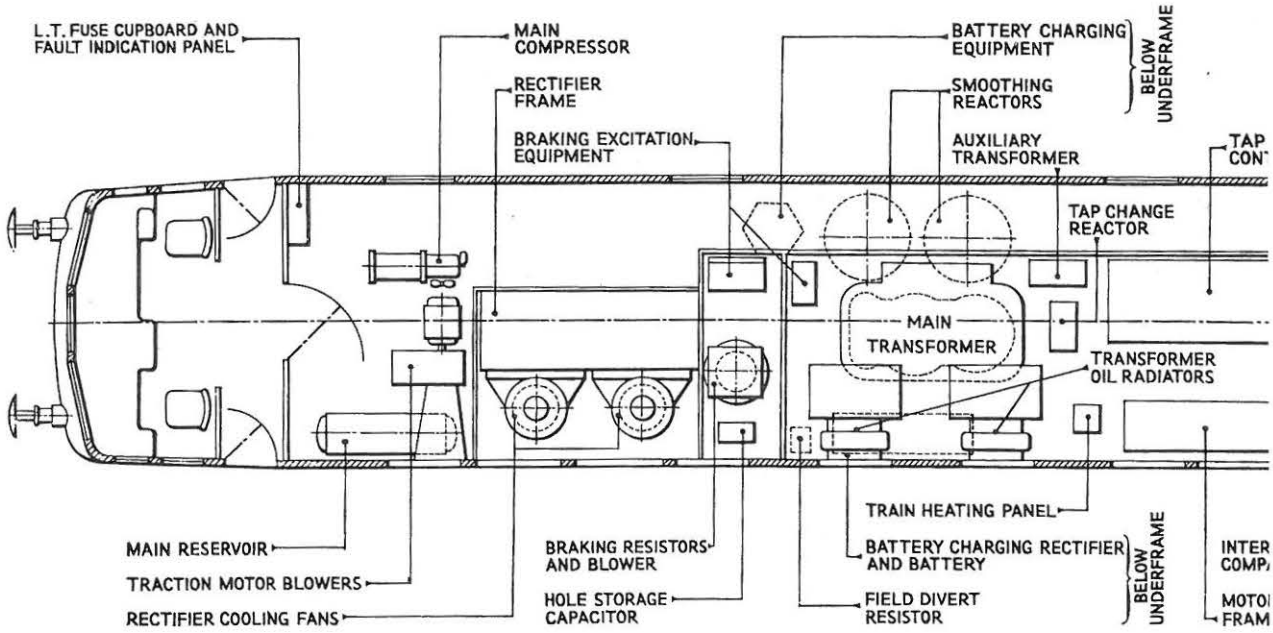
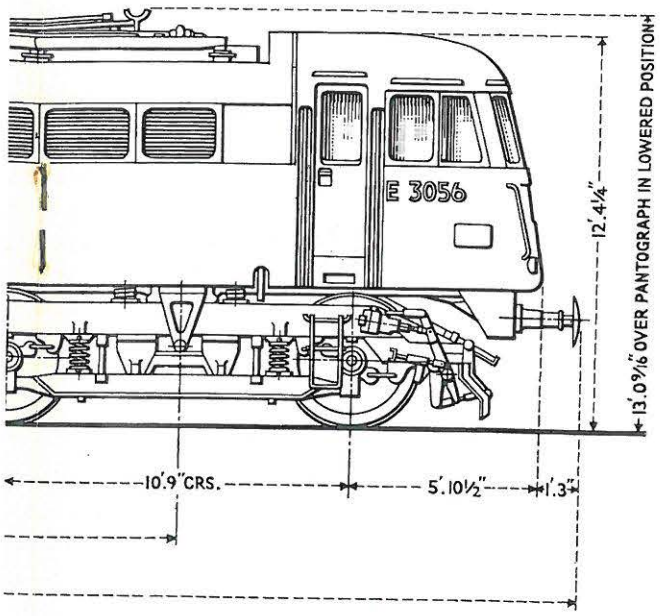
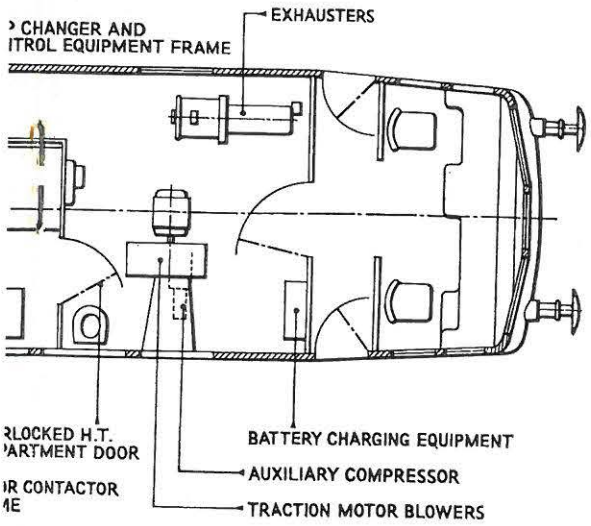


Elevation and plan of locomotive, showing principal dimensions and general arrangement of equipment



Nº 2 END



and the underframe to form a deep trough section structure. The complete roof and top portion of the bodysides down to the bottom of the windows is made up as a light steel frame covered with riveted aluminium panels. Welded aluminium roof traps are fitted to facilitate the removal of individual items of equipment. The lower bodyside panels are in $\frac{5}{16}$-in. steel plate, flanged at the top to provide stiffness and a seating for the roof unit.

Underframe Assembly

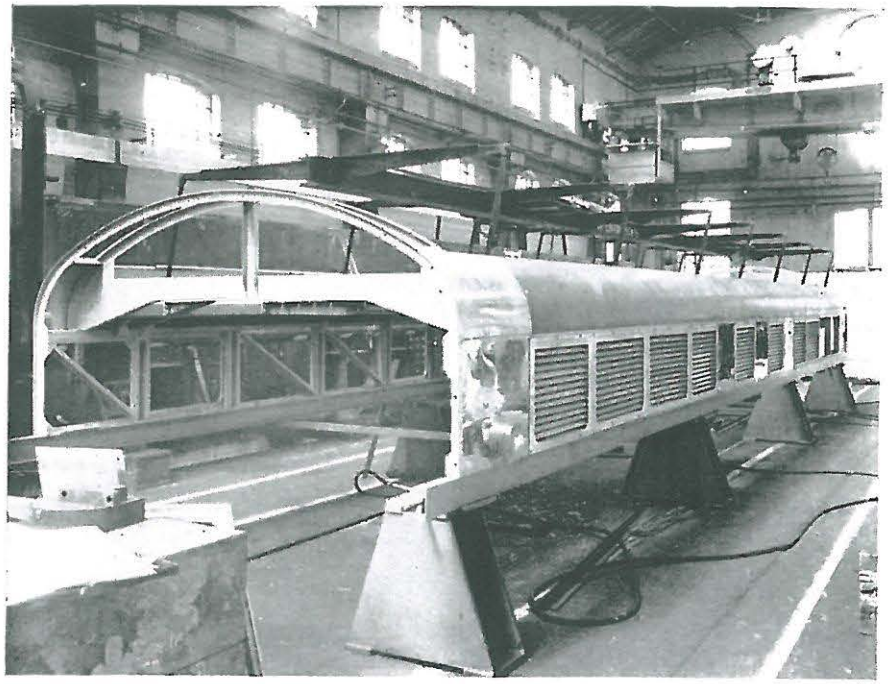
The underframe is a welded assembly of seven box sections, comprising drag box and cabs, bogie centres, intermediate sections and transformer well section. The vertical lateral and longitudinal members are in $\frac{5}{16}$-in. plate and the top and bottom plates are $\frac{3}{8}$-in. thick. Oleo-Pneumatic buffers are fitted, the buffing and drawgear loads being taken on the main frame.

The four-wheel bogies are of the underslung equalizing beam type, the beams being carried from the Timken roller bearing axleboxes on combined shear and compression rubber pads. The Alsthom system of rubber cone pivot body suspension and radius arm guided axleboxes is incorporated. The bogie frame consists of an assembly of rolled steel channel side members, welded to form a box section, and fabricated transoms and headstocks. Four double-coil helical springs support the bogie frame on the equalizing beams.

The body is carried on each bogie on a double-ended cone rubber pivot fitted into the top and bottom centre members. A transverse spring anchorage maintains the vertical alignment of the pivot. A proportion of the body load is transmitted to the bogie through four spring-loaded side bearers, fitted with manganese rubbing plates. Rubber bushes are used wherever possible to cushion the loads and to eliminate lubrication. Sanding is applied to the outside wheels of each bogie.

Brake equipment

The brake equipment provides for air braking on the locomotive and vacuum braking on the train. Rheostatic braking is incorporated in the power circuits to reduce the tyre and brake block wear on long down grades. When hauling vacuum braked stock the locomotive air brakes are controlled by the driver's vacuum brake valve. An independent airbrake valve is fitted for use when running light and when hauling unbraked trains. A braked/unbraked switch is fitted to control the application rate of emergency applications when hauling unbraked stock. The antislip brake, giving



Complete roof and top bodysides made as a light removable unit

a partial brake application to check wheel slip, is push button controlled.

The clasp brake rigging on each bogie is operated by four externally mounted 8-in. dia. cylinders with slack adjusters incorporated. Renewable cast-iron brake shoes are fitted, and self-lubricating bushes are used in the brake rigging to reduce maintenance. All equipment, which is of Westinghouse design and manufacture, is of the latest light-weight type incorporating synthetic rubber valve seats and rubber diaphragm operated valves.

Air for the brakes and other services is supplied by a motor-driven type 2.E38 two-stage compressor, the main reservoir pressure being automatically maintained between 85 and 100 lb. per sq. in. Vacuum for the train brake operation is created by two type 4V.110 two-speed exhausters. These normally run at 600 r.p.m. but may be speeded up to 1,200 r.p.m. for quick brake release by depressing the brake valve handle. When passing through a neutral section one exhauster only is run from the battery to maintain the train pipe vacuum. The handbrake, applied to one axle per bogie, is operated from the cab through a chain drive to a shaft fitted with universal couplings.

Rheostatic brake

The rheostatic brake, in which the traction motors are switched to function as generators driven by the wheels, provides a braking effort of 24,000 lb. between 10 m.p.h. and 21 m.p.h., dropping to 8,000 lb. at 70 m.p.h. Braking is controlled by the master controller handle, a selector switch being fitted to enable the braking or power circuits to be selected. The four traction motor fields are connected in series, excitation being provided by a step-down transformer. Current is dissipated in a force-ventilated resistor connected across each armature, the cooling fan delivery being automatically regulated to suit the amount of coiling required.

Air is drawn through the underframe and, after passing through the vertical stack of resistors, is discharged through hinged louvered flaps in the roof.

PRINCIPAL SUBCONTRACTORS

Main electrical equipment	Associated Electrical Industries (Rugby) Limited
Brake equipment	Westinghouse Brake & Signal Co. Ltd.
Axleboxes	British Timken Division of the Timken Roller Bearing Company
Buffers	Oleo Pneumatics Limited
Radiators	Serck Limited
Drop windows	Beckett, Laycock & Watkinson Limited
Front window heater	AEI (Manchester) Limited
Windscreen wipers	Trico Folberth Limited
Bogie pivot rubbers	Empire Rubber Co. Ltd.
Pantographs	J. Stone & Co. (Deptford) Ltd.
Air-blast circuit breakers	Brown Boveri & Co. Ltd.
Traction motor blowers, and transformer and rectifier fans	Aerex Limited
Batteries	Nife Batteries Limited
Cab instruments	Nalder Bros. & Thompson Ltd.
Route indicators	Transport Engineering & Equipment Company
Hydraulic dampers	Woodhead Monroe Limited

H.V. a.c. locomotives built by British Railways

For further information on this equipment write to :
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