AEI

A.C. TYPE 'A' ELECTRIC LOCOMOTIVES FOR BRITISH RAILWAYS, Nos. E 3001—E 3023

Associated Electrical Industries Limited

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A.C. ELECTRIC LOCOMOTIVES FOR BRITISH RAILWAYS

25-kV 50-c/s system

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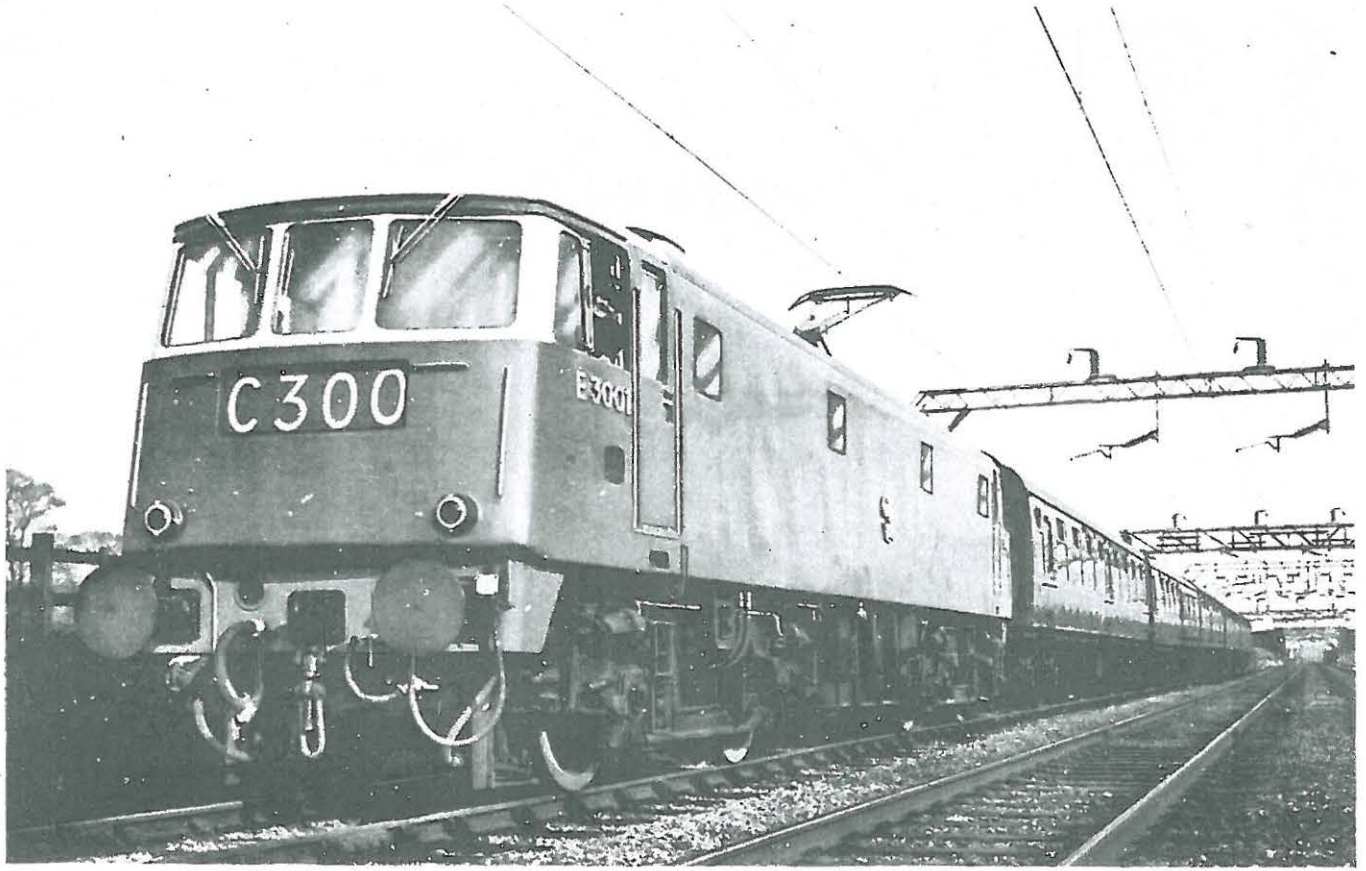
ASSOCIATED ELECTRICAL INDUSTRIES LTD.
TRACTION DIVISION

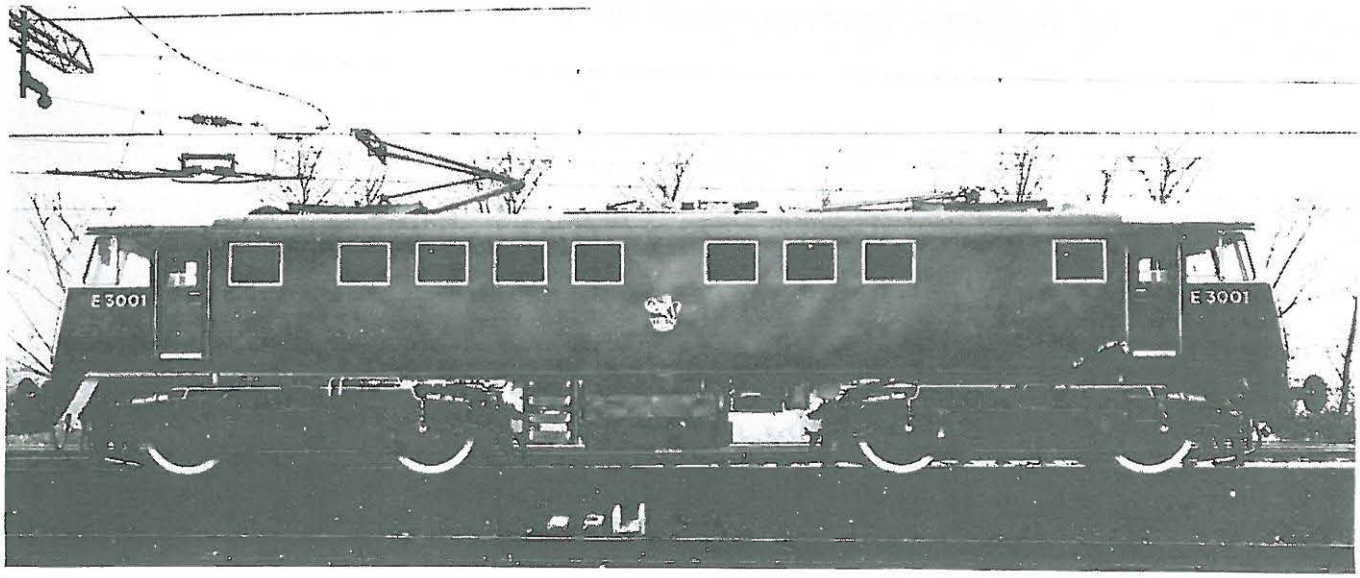
Rugby **MANCHESTER** **London**



Thirty-five complete 3,300-*h.p.* 25-*kV a.c. locomotives, and forty sets of electrical equipment are being supplied by the AEI Traction Division to British Railways*

First A.C. Electric Locomotive for British Railways

London Midland Region type "A" 3,300-h.p.
80-ton 25-kV. 50-cycle a.c. unit



British Railways type "A" 3,300-h.p. 25-kV. 50-cycle a.c. electric locomotive, one of 23 being supplied by Associated Electrical Industries Limited for service in the London Midland Region

IN connection with the modernisation plan for British Railways, the British Thomson-Houston Co. Ltd., now incorporated in the Associated Electrical Industries Traction Division, is supplying 25 complete a.c. electric locomotives, the mechanical parts for which have been sub-contracted to The Birmingham Railway Carriage & Wagon Co. Ltd. There will be 23 type "A" locomotives, and the remaining two to be delivered later will be of British Railways type "B" designation.

The specification for the type "A" locomotive requires that it shall be capable of hauling a 475 ton passenger train at 90 m.p.h. and a 950 ton mineral train at 55 m.p.h. The unit is of the Bo-Bo type equipped with four series-wound traction motors mounted on two fabricated bogies, and the nominal weight is 80 tons. The type "B" unit is identical except for the gear ratio which is arranged for a maximum speed of 80 m.p.h.; it will be capable of hauling mineral trains of up to 1,250 tons at a speed of 55 m.p.h.

Locomotive Layout

The locomotive is of the double ended type and the driving compartments at each end are connected by a corridor. Behind each driving compartment is a space in which are housed the compressor, exhausters, traction motor blowers and other equipment. The centre compartment, to which access is gained through an interlocking door at No. 2 end, houses the control gear, transformer, and rectifiers. The interlocking allows access to the compartment only when the pantographs are lowered and the h.t. equipment earthed. The control and transformer compartments are caged in a full height aluminium expanded metal enclosure. The rectifier compartment is sealed by an enclosure of sheet aluminium panels.

The locomotive is designed primarily for operation at a line voltage of 25 kV. 50 cycles. It also has to operate with full output at 6·25 kV. because certain sections of the overhead line have limited electrical clearance and are fed at this reduced voltage. This is achieved by arranging the main transformer primary winding in four sections, connected in series for a 25 kV. supply and in parallel for a 6·25 kV. supply. This is effected automatically by an oil-immersed off-load changeover switch.

For the transformer oil cooling, two Serck radiators, connected in series, are fitted under the roof. Mounted at deck level is a 300 g.p.m. Pulsometer circulating pump driven by a B.T.H. motor. An expansion tank is mounted on No. 1 cab bulkhead. Each radiator is cooled by an Aerex axial flow fan, drawing air through the bodyside and up through the horizontal radiator. Discharge through the roof is via a louvred hood, moulded in glass fibre, which is above both radiators.

Current Collection

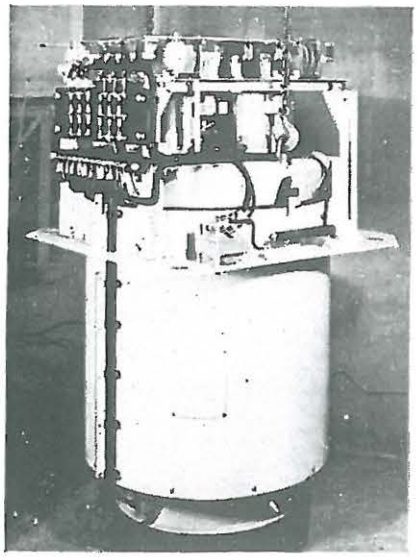
Current collected from the overhead wire by pantographs of the Stone-Faiveley AMBR pattern is fed through a Brown Boveri air-blast circuit breaker mounted on the roof to the main transformer. The output of the transformer is converted to direct current for the traction motors by three air-cooled six-anode pumpless steel-tank mercury-arc rectifiers, diametrically connected in parallel so that each tank has three anodes in each half cycle. Load sharing reactors are provided to ensure current sharing between tanks and individual anodes. Smoothing chokes are also provided.

Rectifier Cooling

Each of the three rectifiers has an independent automatic temperature control system. An Aerex fan draws air through the body side and this is trunked to the base of the rectifier, through which it discharges upwards into a roof chamber which is vented to atmosphere. On the suction side of the fan ducting is an opening into the roof chamber. In this opening is an electric heater. Thermostatically controlled shutters are fitted to the heater and on the bodyside louvres. When starting up from cold the bodyside shutters are closed and the heater panel shutters open. Air is then circulated by the fan on a closed circuit through the heater and rectifier. At a temperature determined by thermostats the heaters are switched off, and a short circuiting contactor closes across the traction motors enabling the rectifier heating to be continued by passing a low voltage current through them. This contactor has interlocks which ensure the traction motor reversers are in mid position to open the motor circuits. When normal working temperature is reached the thermostat switches off the heater. When higher air temperatures are reached, other thermostats close the heater panel shutters, and open the cold-air inlet shutters in the bodyside.

Traction Motors

The four traction motors are connected permanently in parallel. They are six-pole series wound machines specially developed for operation on a rectified



Air-cooled six-anode pumpless steel-tank mercury-arc rectifier

50-cycle single-phase supply. The motors are forced ventilated and designed for long periods of operation between overhauls. This has been achieved by using, among other things, class "H" insulation and special lubrication arrangements. The ratings of the motors are as follow:

Continuous rating	... 975V.	700A.	847 h.p.
One-hr. rating ...	... 975V.	760A.	920 h.p.
Gear ratio type "A"	... 29/76		
Gear ratio type "B"	... 26/83		

One traction motor blower is fitted behind each cab bulkhead. Also fitted in the compartment behind No. 2 cab are the two tier-mounted exhausters and a small battery-driven Clayton compressor. This provides an emergency air supply for raising the pantograph in the event of a fully discharged main reservoir.

Control Equipment

A camshaft control unit, actuated by the driver's master controller, provides 37 accelerating notches and two field-weakening notches. Voltage control is by on-load tap-changing on the low-voltage side and the output is fed to the rectifiers through two high-speed circuit breakers, thus rendering anode fuses unnecessary. Besides giving protection against back-fires, these breakers are also used as contactors during ordinary locomotive operation so that no individual motor contactors are provided.

The two traction motor blowers, three rectifier cooling fans, two transformer oil cooling radiator fans, and the transformer oil circulating pump are driven by a.c. motors. One exhauster is battery fed; the other exhauster and the compressor are fed from the a.c. supply through germanium rectifiers. The battery is floating continuously on a battery charger of the magnestat type which also incorporates a germanium rectifier.

The principal characteristics of the locomotives are as follow:

	Type "A"	Type "B"
Wheel arrangement ...	Bo-Bo	Bo-Bo
One-hr. rating	3,680 h.p.	3,680 h.p.
Continuous rating ...	3,300 h.p.	3,300 h.p.
Top speed	100 m.p.h.	80 m.p.h.
Weight	80 tons	80 tons
Maximum tractive effort at peak notching current ...	48,000 lb.	60,000 lb.
Tractive effort at continuous rating of motors	20,000 lb.	24,000 lb.
Speed at continuous rating of traction motors	60 m.p.h.	49 m.p.h.

Locomotive Superstructure

The complete body of the locomotive is designed as a weight-carrying structure. Each side of the body takes the form of a deep lattice girder with diagonal and vertical "I" section members, to which the 12-gauge skin is attached. The two sides are braced together at roof level with a series of formed members, thus forming a rigid box structure of minimum weight for the support of the main frame and equipment.

The roof height of the power compartment is limited by the safety clearance required between the roof equipment and the high-voltage overhead supply line, and to provide a comfortable working height in the cab, the cab roof is extended above the main roof height. To improve the appearance of the stepped roof a glass-fibre fairing, moulded to the corner radius, extends for the full length between the two cabs.

The cab roof is a double-skin glass-fibre moulding. At the cab front there is a three-piece screen, the driving panels being fitted with pneumatic wipers. These screens incorporate a layer of transparent gold film in the laminations which forms an electric heating element to act as de-icer and de-mister. Full drop windows are fitted in the cab doors and adjacent to the seats. These side windows are also fitted with hinged two-position draught deflectors.

The power compartment roof is made in five detachable sections, some of which are constructed in glass fibre and the others in steel. Four fixed windows are fitted on the corridor side of the body and nine louvred air intakes on the opposite side. Rubber water drainage pipes are taken from these, and from the pantograph roof well, down the inside of the body. Recessed code lamps and destination indicators are fitted at the front of each cab.

Cab Layout

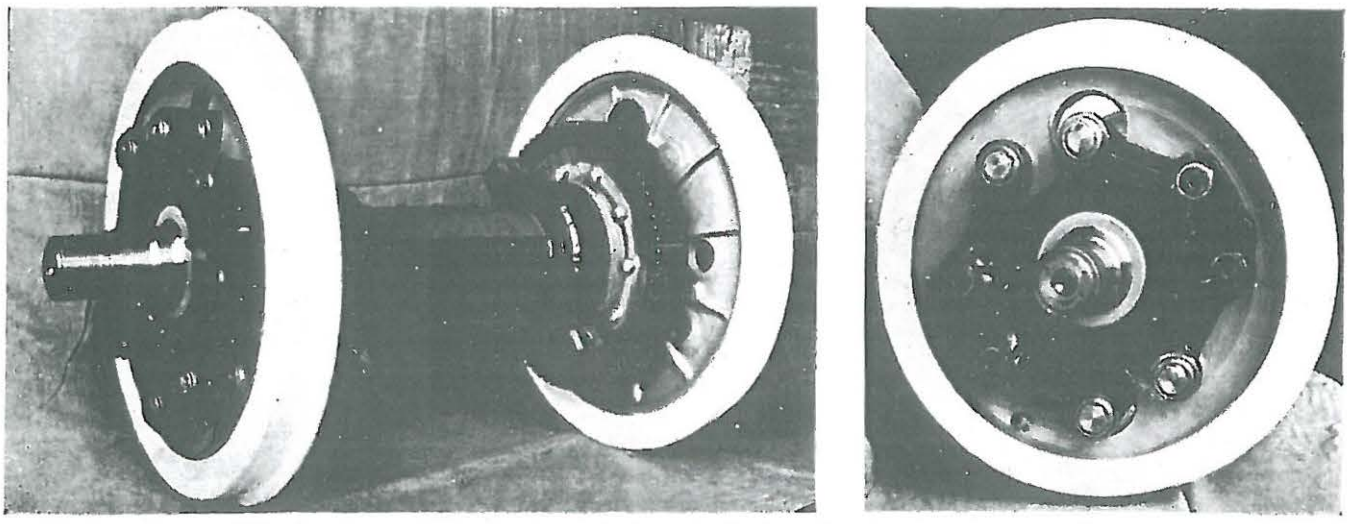
The driver's seat fitted at the left hand side is upholstered and fully adjustable. On the opposite side is a similar seat for a second man. A full height glazed screen is fitted behind each seat and on this is mounted a heater. Similar heaters are fitted below each side window and on the rear bulkhead. Also on the rear bulkhead is the handbrake wheel.

The driver's controls are positioned on a flat top knee-hole type desk, with the air brake and vacuum brake valves on the left and the speed controller and reverser on the right. The driving instruments and brake gauges are carried on a sloping facia panel mounted below the windscreen. Three ceiling lights are fitted. The cab floor is in natural finish maple, grooved to provide a tread pattern surface.

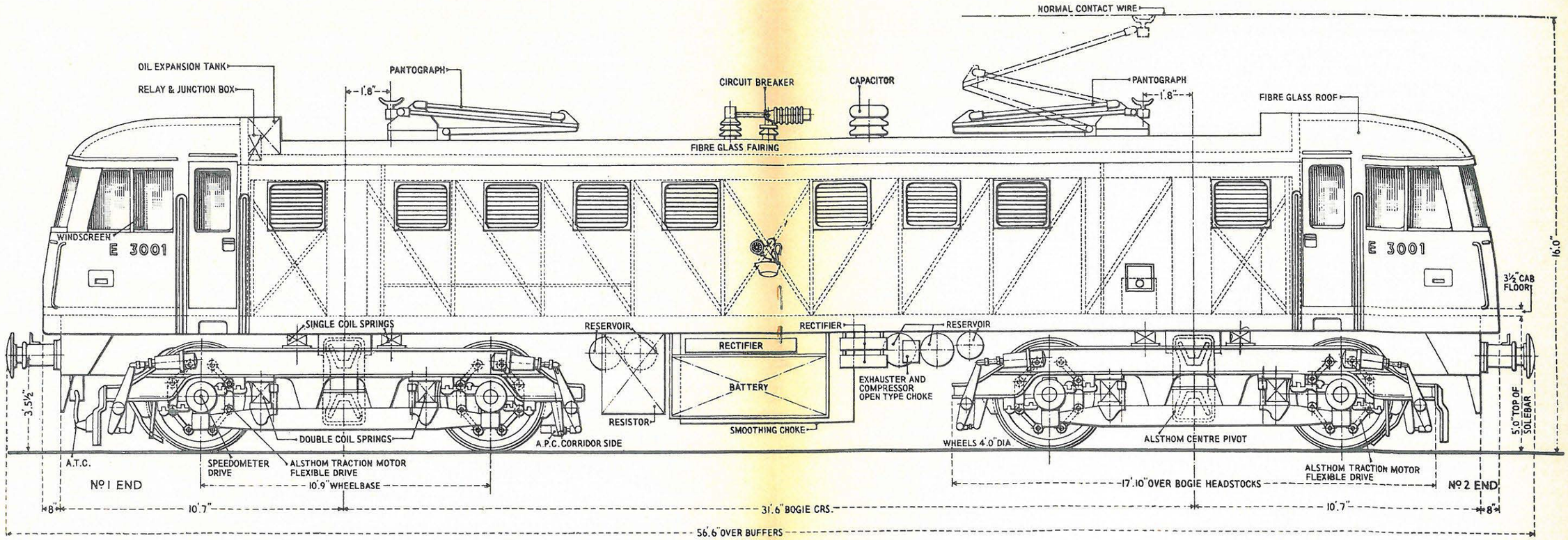
Bogies and Body Suspension

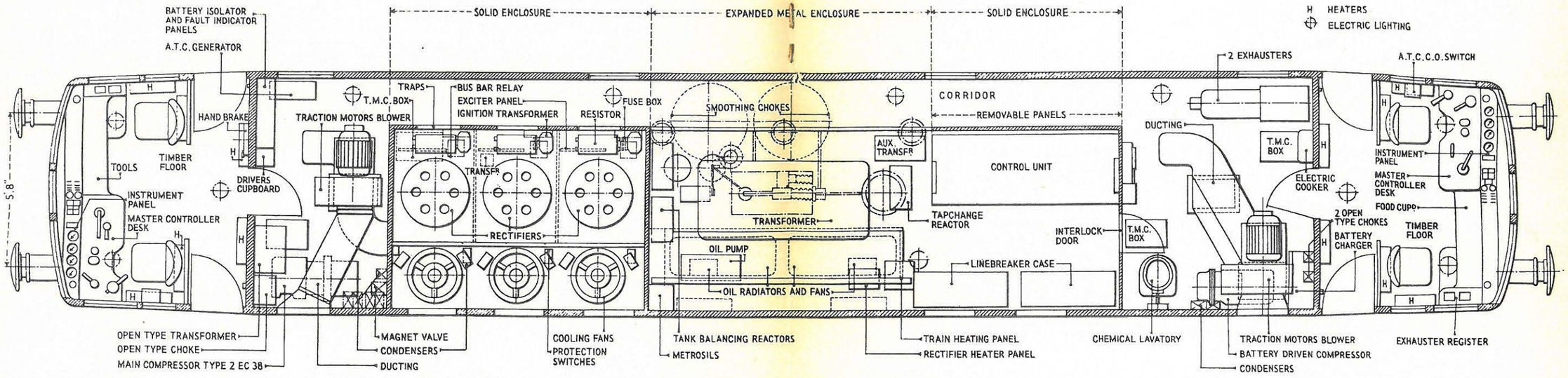
Used in service for the first time on a British Railways locomotive is the Alsthom system of rubber cone pivot body suspension, radius arm guided axle boxes, and flexible link drive to the wheels. These features combine to give good riding characteristics and reduce unsprung weight, and maintenance costs.

The four-wheel bogies of the



Wheel and axle set, left, and end view of wheel, right, showing Alsthom drive



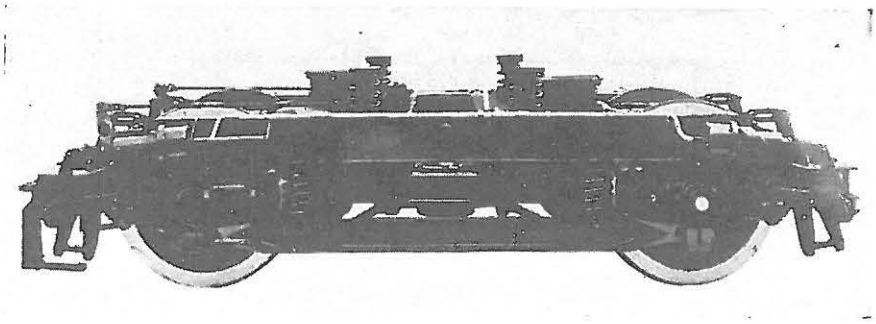


BRITISH RAILWAYS TYPE "A" Bo - Bo 3,300-H.P. 25-kV. 50-CYCLE A.C. ELECTRIC LOCOMOTIVE

underslung equalising beam type are Corten steel welded fabrications. Solebars and main members are of hollow box formation. The bogie frame is supported on four nests of double coil helical springs from the low-level equalising beams. Shock absorbers are fitted and the rise of the primary springing is checked to maintain clearance within the quill drive of the traction motor.

The equalising beams are carried from the axleboxes on combined shear and compression rubber pads which, in conjunction with the fully sprung traction motors, reduce deadweight on the track to a minimum.

No fixed guides are used for the S.K.F. roller bearing axleboxes, each box being carried by two Silentbloc-bushed radius arms anchored to the bogie frame. This cushions the fore-and-aft forces and provides a degree of lateral resilience which reduces wheel flange wear.



Locomotive bogie, showing the two rubber cone pivots and four spring-loaded side bearers

Bogie Pivot

On each bogie the body is carried on a double-ended cone rubber pivot, fitted in a fabricated carrying member which is transversely anchored to the underframe through spring loaded units. The 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. The side bearers, fitted with manganese wearing pads, are mounted on the bogie frame and arranged so that the proportion of load carried on the bearers can readily be adjusted. Lubrication has largely been eliminated by the use of rubber bushes, but where required Tecalemit lubrication is provided.

The traction motors are resiliently suspended on the bogie frame on three-point mountings, no vertical thrust from the motors being transmitted to the axles. The two suspension points at the crossbars are of conical form to insulate the motor from horizontal shock loading.

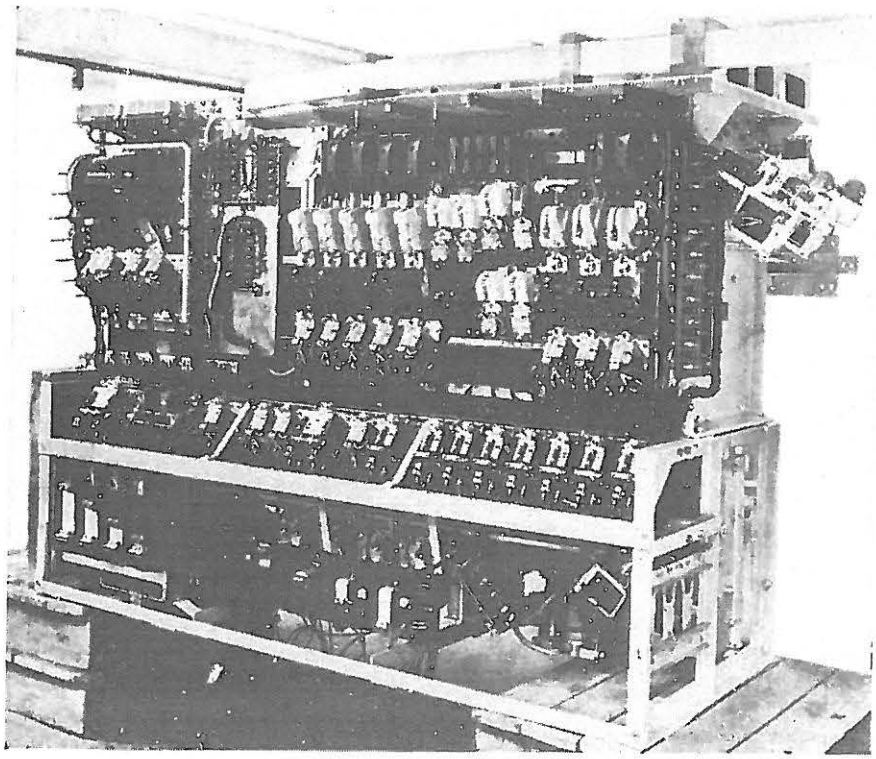
From the reduction gear on the motor the drive is taken through a hollow shaft to a universal link assembly, which in turn drives the wheel. Four links are used, bushed at each end with a Silentbloc bush. The drive ends of one pair of links are attached to the hollow shaft of the reduction gear, and the ends of the other pair to drive pins attached to the wheel. The inner ends of the four links are anchored to a floating ring on the outside of the wheel. This arrangement provides a cushioned drive between motor and wheel and permits free vertical movement of the axle. The use of rubber bushed pivots eliminates all lubrication of the linkage.

Welded Underframe

The underframe is a welded structure of 8 in. by 3½ in. channel section longitudes and 8 in. by 3½ in. angle section crossmembers. An inner and outer solebar form continuous members at each side. These are butt welded to the box-section headstocks, which are fabricated in ⅜ in. plate. A robust plate fabrication forming the draft bar is fitted between the headstock and bolster. In the centre of the frame is a recess for the transformer and extending from this recess to each bolster are two channel section longitudes. All openings between the members are filled with 12-gauge steel plate, forming a flush deck. The sandboxes are incorporated in the box-section headstocks. Standard draw-gear and couplings are fitted, together with Oleo Pneumatic buffers.

Brake Equipment

The system comprises a vacuum controlled straight air brake which operates an air pressure brake on the locomotive in conjunction with a vacuum brake application on the train. An independent air-brake valve is fitted for use when running light and when hauling unbraked trains. All equipment, which is of West-



Camshaft and control frame

inghouse design and manufacture, is of the recently introduced lightweight type incorporating synthetic rubber valve seats and rubber diaphragm operated valves instead of pistons.

The clasp brake rigging on each bogie is operated by four externally mounted 8 in. dia. type " J.S." combined brake cylinders and slack adjusters. Operating at a maximum pressure of 70 lb. per sq. in. the nominal brake force is equivalent to 85 per cent of the locomotive weight. The brake blocks consist of cast steel heads and renewable cast-iron shoes.

Air for the locomotive brakes and other pneumatic equipment is provided by one type " 2 EC 38 " compressor, driven by an integral electric motor operating off the low-voltage control system. The major components of this new two-stage compressor are made in light alloy, and a compact intercooler is incorporated.

Vacuum for the train brake operation is created by two type " 4 V 110 L " reciprocating exhausters. These are driven by flange-mounted B.T.H. motors, arranged for two-speed operation, and fed from the low-voltage control supply. The change from the normal low-speed running to the higher speed for brake release is controlled automatically by switch contacts on the driver's vacuum brake valve. To facilitate uncoupling from a braked train, provision is made for releasing the locomotive brakes independently of the train brakes.

Two rates of deadman's brake application are provided on the locomotive to suit the class of train being hauled. Selection is by the Braked/Unbraked changeover switch. This does not affect the driver-controlled braking, but allows a slower rate of application of the deadman's brake when hauling unbraked stock. During a deadman's application the traction circuits are automatically broken by the vacuum control governor. Chokes are fitted at suitable points in the system to ensure that in the event of a hose coupling failure, the full braking remains available on the unaffected bogie. The two brake supply reservoirs are 15 in. dia. by 36 in. long and the two main reservoirs are 15 in. dia. by 48 in. long. Considerable weight saving has been achieved by constructing these reservoirs in high-grade stainless steel. The handbrake is arranged to operate, through the power brake rigging, on the outside wheels of the adjacent bogie.

The locomotive has been designed to the general requirements of the British Transport Commission under the overall direction of Mr. S. B. Warder, Chief Electrical Engineer, British Railways Central Staff.

The principal sub-contractors are as given on the facing page.

Issued by:

A E I TRACTION DIVISION
Manchester 17, England

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PRINCIPAL SUB-CONTRACTORS

Mechanical equipment (including drawgear)	The Birmingham Railway Carriage & Wagon Co. Ltd.
Rubber elements in drawgear	George Spencer, Moulton & Co. Ltd.
Transformer oil coolers	Serck Limited.
Pantographs	J. Stone & Co. (Deptford), Ltd.
Air-blast circuit breaker	Brown Boveri & Co. Ltd.
Transformer fans, rectifier fans, traction motor blowers	Aerex Limited
Battery	Nife Batteries Limited.
Capacitors	British Insulated Callender's Cables Limited. Telegraph Condenser Co. Ltd.
Train heating jumpers	General Electric Co. Ltd.
Auxiliary compressors	Clayton Dewandre Limited.
Cable	Associated Electrical Industries (Woolwich) Limited.
Brakes, including compressors and exhausters	Westinghouse Brake & Signal Co. Ltd.
Wheels and axles	Owen & Dyson Limited.
Buffers	Oleo Pneumatics Limited.
Quill drive links	Silentbloc Limited.
Axleboxes	Skefko Ball Bearing Co. Ltd.
Bogies centre pivot rubbers	Empire Rubber Co. Ltd.
Motor supports, etc.	Metalastik Limited.
Springs	Wilfords & Co. Ltd.
Cab instruments	Nalder Bros. & Thompson, Limited. Record Electrical Co. Ltd. Westinghouse Brake & Signal Co. Ltd.
Windows	Beckett, Laycock & Watkinson Limited.
Glass fibre mouldings	The Birmingham Railway Carriage & Wagon Co. Ltd.
Windscreen wipers	Trico Folberth Limited.

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