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Locomotives: Nos.E 3024/35 E 3303/5 (E.E. Co.)

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1. Introduction

This paper describes the A.C. locomotives built by the English Electric Group of Companies for the British Railways Modernisation programme. The order was for the design and manufacture of fifteen locomotives to specification AC3 of the British Transport Commission which called for certain performances given in Paper 3.

All fifteen locomotives have identical equipment and mechanical parts except that twelve are geared for 100 m.p.h. maximum service speed (type A) and three for 80 m.p.h. only (type B) but of course with increased rated tractive effort. Unless otherwise stated, references are to the type A.

2. Leading Particulars

The leading data and particulars for the type A locomotives shown in fig.1 based on a line voltage of 22·5 kV, 100 per cent secondary tappings, and half-worn wheels, are as follows:

Total weight	73·0 tons
Maximum axle load	18·3 tons
Weight of electrical equipment (including drive)	37·0 tons
Weight of two bogies (excluding motors and drive)	19·5 tons
Weight of underframe and body	16·5 tons
Length over buffers	52′ 6″
Bogie wheelbase	10′ 0″
Bogie centres	30′ 0″
Wheel diameter (new)	48″
Gear ratio	25:76
Maximum service speed	100 m.p.h.
Maximum accelerating tractive effort (average)	40,000 lbs.

Continuous rating at wheel:

	Full Field	*Weak Field*
Tractive effort	20,000 lbs.	15,260 lbs.
Speed	55 m.p.h.	72·6 m.p.h.
Power	2,940 h.p.	2,950 h.p.

The layout of equipment together with side and front elevations of the locomotive are shown in fig.2.

Fig.3 shows the locomotive performance curves. Additional notches are provided to give approximately 5 per cent increase in voltage if required, i.e. approximately 105 per cent.

3. Description of Circuits

3.1 *Power Circuits*

These are shown in fig.4.

Low-voltage control is attractive for B.T.C. conditions as such equipment allows full rated output on both 25 kV and 6·25 kV without increase in weight. Because of this, and also the known inherent advantages which low-voltage control gives regarding power factor and efficiency, this system was adopted for the locomotives.

Current is collected by either of the two pantographs and feeds the primary winding of the transformer through an air-blast circuit-breaker and a supply change-over switch which connects four equal sections of the primary in series for 25 kV or in parallel for 6·25 kV.

A condenser divider provides a suitable voltage for the operation of four detector relays associated with the control of the supply changeover switch.

The rectifiers are connected in two 3-wire bridge groups and the two traction motors of a bogie are permanently connected in series across a bridge. The centre points of the motor circuits are connected to the centre point of the transformer secondary and also to earth. Hence the motors are effectively in parallel, making them less sensitive to wheel slip, and their voltage to earth is limited to a reasonable value.

Transfer from one transformer tapping to another is by closed circuit transition using resistance and reactance; the reactance is left in circuit to give intermediate notches. Cam-operated contacts are used to select tappings and electro-pneumatic contactors are used for making or breaking the circuit.

At the continuous rating the current to be handled on the low tension side of the transformer is approximately 1,400 amps. By inserting the resistor to limit circulating currents during transition, contact wear is reduced.

Asymmetric tap changing is used, each tap change affecting all four motors equally, but above half voltage the symmetrical conditions only are available as running notches in order to produce the best traction motor performance. Transformer tappings and selector contacts are used twice during acceleration, by using the tapped secondary windings first alone and then in series with equal untapped windings. The transition is effected by a winding grouping switch whose contacts do not make or break current and which also allows two reactors to be included in the commutating circuit up to half voltage. These reactors serve to steepen the locomotive speed/current characteristics at the lower speeds and so reduce the notching peaks.

Two rectifiers operating bi-phase match satisfactorily the traction motor for voltage and current ratings, and are so used here. In order to rate the transformer at a kVA corresponding to bridge connection, the rectifiers supplying two of the motors are reversed in polarity. The result is the 3-wire bridge circuit shown in the diagram.

There are 38 economical notches with motors in full field. Two others are obtained by field tap, one at reduced volts and the other at maximum volts.

A smoothing reactor is arranged in series with each motor to reduce the current ripple to a value which is reasonable for motor operation. Four ammeters, one for each motor, are fitted in each driving cab, and indicate any mal-operation of the ignitrons, as well as indicating wheel slip.

3.2. *Auxiliary Circuits*

These are shown on diagram, fig.5.

The main transformer has an additional winding for train heating and another for auxiliary supplies.

The former provides current for train heating through two contactors. Protection is by fuses and an overload relay.

The Arno set consists of an Arno convertor direct coupled to a D.C. generator and a small tachometer alternator. The battery is used to run the Arno set up to near synchronous speed, using the generator as a motor. At the appropriate speed the tachometer alternator causes the single phase supply to be switched on to the Arno and opens the D.C. starting contactor. The Arno then drives the generator which is automatically connected to the battery and floats under automatic carbon pile voltage regulator control at 110V. The oil and water pump motors, being small machines, are permanently connected to the Arno 3-phase supply and run up as soon as the single phase supply is connected. The fan motors and blowers are connected to the Arno in sequence with a time interval between each, controlled automatically by a time delay relay. This scheme permits the use of simple machines without commutators or capacitors and gives constant speed to the A.C. connected auxiliaries; hence the cooling of apparatus is not dependent on line voltage.

The compressors and exhausters are D.C. machines. One exhauster is connected across the battery so that it can continue to run on loss of line volts. The small auxiliary compressor is also connected to the battery.

By earthing one pole of the single phase supply the A.C. auxiliary machines can be controlled by 2-pole contactors and fully protected by 2-pole circuit breakers.

4. Description of Electrical Apparatus

4.1 *Roof Mounted H.T. Equipment*

There are two Stone-Faiveley type AMBR pantographs, a Brown Boveri DBTF air-blast circuit-breaker and a Telegraph Condenser Co., Ltd capacity divider mounted on the roof. See Papers 3 and 20 for details. The transformer primary H.T. bushing protrudes through the roof; the series/parallel change-over switch is mounted on one end of the transformer.

4.2 *Main Transformer*

This, illustrated in fig.6, is of the shell type with forced oil cooling and a separate blown radiator. The core is built up of grain-oriented silicon iron and is clamped without through-bolts; corner supports are provided to prevent movement of laminations in the horizontal plane.

The lower part of the tank forms a support for the core and windings; the upper part carries epoxy-resin moulded secondary terminal blocks, the H.T. bushing, and various fittings.

The transformer rating to I.E.C.77 is:

Winding	*Primary*	*Secondary*	*Train Heating*	*Auxiliary*
Rated voltage	25/6·25 kV	2,540V	906V	498V
Rated kVA	3,700	3,700	362	185

The transformer reactance is 10 per cent.

4.3 *Tap-changer*

The tap-changer is a cam-operated controller in two halves on a frame with the engine and gears arranged between two camshafts, see fig.7. The main contacts are of the silver butt self-aligning bridge type. The main camshafts are operated through Geneva gears and movement is alternate so that only one camshaft moves at a time. The engine consists of three oscillating cylinders each carrying a piston and piston rod and arranged symmetrically around a crankshaft carrying the first driving gear. The engine is operated by control air through a reducing valve and is controlled for forward or reverse rotation by standard magnet valves. Position regulator contacts and electrical interlocks are operated by two additional camshafts which are driven through conventional gears from the engine. The whole mechanism is light and of low inertia so that stopping time is extremely small, stopping being effected by simply cutting off the air supply. Brakes are unnecessary.

Incorporated in the camshaft frame are the winding grouping switch for the transformer, the reverser and field tap switch and various control relays.

All current making and breaking is carried out by a total of ten electro-pneumatic contactors which are operated from the camshaft position regulator contacts. These contactors have laminated magnetic circuits for blow-out, silver butt current carrying contacts and easily replaceable arcing tips.

4.4 *Rectifiers*

The locomotive contains two rectifier cubicles each containing four sealed ignitrons connected in a bridge circuit, see fig.8. Each pair of ignitrons in effect feeds one traction motor.

The ignitrons are water cooled units 8 in. diameter and 32 in. high overall. Each tank contains two ignitors, one relieving anode and one energised grid, in addition to the anode and the cathode. The vacuum vessel is of stainless steel and 'Kovar-glass-kovar' high temperature seals are used for the electrode insulation.

A water jacket with spiral guides surrounds the vacuum vessel and the cathode block is also water cooled. Heaters around the anode insulation prevent condensation of mercury in these areas. The cooling water is pumped through a fan-cooled radiator and thence to a distribution manifold which contains the water heaters. From this manifold, rubber pipes carry the water to the rectifiers and thence to the suction side of the pump. Special non-destructible targets are used at each end of each rubber tube. Thermostats in the suction manifold ensure that the water heaters are switched on and load application is prevented until the correct operating temperature is achieved, and thereafter, the water temperature is automatically controlled by a wax-bulb operated valve in the radiator by-pass circuit. The water is treated with ethylene glycol and sodium tetraborate inhibitor.

4.5 *Reactors*

All reactors are situated in one tank and are oil cooled in series with the main transformer. The four D.C. smoothing reactors are each of about 3·1 mH at rated current and are specially arranged so as to practically eliminate stray fields and mutual inductive effects.

The two dropping reactors and two tapping reactors are each three limb laminated cores with air gaps.

4.6 *Drivers Controls*

These are of the standardised type described in Paper 3.

4.7 *Traction Motors*

The EE535A traction motor is a 4-pole D.C. machine motor, conventional in almost all respects. The frame is designed for mounting in the bogie frame and for use with the SLM Brown Boveri resilient drive. There are two support arms on the axle side, one of which is purely to carry the motor, the other the SLM Brown Boveri stub shaft and gear case.

The motors are continuously rated at 750 shaft H.P., 837 volts 707 amps mean when in full field and carrying undulating current with forced ventilation of 3,500 c.f.m. This rating corresponds to a line voltage of 22·5 kV. The permissible temperature rises of armature and fields are 150° and 160°C respectively. The motors operate very satisfactorily with a ripple in the current of approximately 30 per cent at the continuous rating.

It has fixed brushgear employing brushboxes with 'clock' type springs. Braids are fitted to the contact finger of the spring to carry current to the brushbox. Circumferential stagger of the brushes is used, there being three 4-part brushes per brush-arm, of which one 4-part brush is staggered. One spring per pair of carbon pieces is fitted; pigtails are not fitted to the brushes.

The armature is lap-wound and is equalised at the commutator end for each slot. Twin conductors are used with glass braid covering cranked to enter the commutator risers. Class H insulation is used on the armature and field coils. The armature core and commutator are mounted on a common spider pressed on to the shaft.

The machine is not compensated and the interpoles are laminated. The interpole coil is edge-wound to assist heat dissipation and to reduce eddy losses in the conductors.

The main field coils are conventional three-tier coils with one tapping for the weak field notches.

4.8 *Auxiliaries*

The Arno convertor set comprises three machines:

(1) A single phase/three-phase Arno type convertor.
(2) A D.C. generator.
(3) A small tachometer type alternator.

The set is mounted vertically in the locomotive to save floor space.

The Arno convertor is, in essence, a 4-pole, 3-phase, star-connected, squirrel cage induction motor. The stator windings are specially designed to enable it to run as a single phase motor and to generate a 3-phase electrical output simultaneously. The convertor can supply continuously a connected 3-phase auxiliary load of 60 h.p., in addition to the mechanical load imposed upon it by the D.C. generator.

The D.C. generator is mounted above the Arno convertor, on the same shaft, and has a capacity of 20 kW. Its output is held constant at 110V by an automatic voltage regulator. A series starting winding is incorporated.

The tachometer alternator has a permanent magnet rotor and a 2-pole stator winding, and provides a voltage proportional to speed.

The auxiliaries are as follows:

No. per Loco	*Function*	*Output*	*Supply*	*Rating*	*Speed r.p.m.*
1	Arno convertor	See above	415V A.C.	—	1,490
	D.C. generator	110V D.C.	—	20 kW	—
1	Auxiliary compressor	3 c.f.m. (f.a.d.)	110V D.C.	1·5 h.p.	1,500
1	Main compressor	22 c.f.m. (f.a.d.)	110V D.C.	6·1 h.p.	1,450
1	Water pump (emergency)	—	110V D.C.	0·25 h.p.	725
2	Exhausters	57·5/115 c.f.m. displaced	110V D.C.	2·5/ 5·25 h.p.	715/ 1,430
1	Oil cooler fan	12,000 c.f.m.	415V A.C.	8·5 h.p.	1,475
1	Water cooler fan	12,000 c.f.m.	415V A.C.	6·0 h.p.	1,475
1	Water pump	64 g.p.m.	415V A.C.	1·5 h.p.	2,850
1	Oil pump	350 g.p.m.	415V A.C.	6·0 h.p.	1,420
2	Motor blowers	7,100 c.f.m.	415V A.C.	19·6 h.p.	2,920

The pumps and main compressor are Worthington Simpson, the exhausters are Consolidated Brake and Engineering Co.

A Nife 110V 85 A.H ES 8 nickel iron battery is installed.

5. Protection

Surge protection on 25 kV equipment is by two double rod-gaps, one on the condenser divider for line surges and one on the transformer H.T. bushing for switching surges. A surge arrestor of the silicon carbide type across each rectifier protects against the effects of ion-starvation in the rectifiers.

The secondary circuit earth is made through a contactor and a low impedance earth fault relay operating to open the air blast breaker. The contactor is actuated directly by air from the pantograph cylinders and opens when the pantographs are dropped. An interlock on the contactor also opens the air blast breaker. It thus prevents any circulating currents when the locomotive is being towed and there is an earth fault.

Faults in the transformer are detected by a Buchholz relay. A slow build up of gas produces a warning and sudden production of gas is arranged to open the air blast breaker. An explosion vent, consisting of a pipe with a thin diaphragm covering the end, is arranged to direct any ejected oil onto the locomotive roof from where it is drained to the track.

An over-temperature thermostat is fitted in the transformer oil and on operation opens the tapping contactors and returns the camshaft to its off position, at the same time giving warning to the driver.

A motor flashover going to earth will trip the overloads and the earth fault relay and open the air blast breaker.

Rectifier overload relays in the commutating path protect against back-fires and open the air blast breaker.

The traction motor blowers and the oil cooling fan motors are provided with no-current relays which give warning to the driver if they should stop. The warning is maintained even if the driver switches off the machines immediately after the occurrence of a fault. The water cooling system is fully protected by thermostats.

The control system for the auxiliary machines permits the blowers and fan to be shut down at stations to reduce noise, but a thermostat in the water cooling system can over-rule this control and reconnect these machines if the water temperature reaches a pre-determined value.

It is desirable in the event of loss of supply to maintain water circulation to the ignitrons; therefore a small D.C. motor is provided for the water pump and is automatically connected to the battery if for any reason the supply to the main pump motor fails.

6. Mechanical Parts

Special study of the mechanical design was undertaken to meet the requirements of the specification. By comparison with existing electric locomotives in the same weight bracket it was considered that orthodox construction did not meet the required strength-weight-ratio. The restriction imposed by low overall height in compliance with the British Railways loading gauge, the necessity to provide adequate clearance to earth from the high voltage equipment, accommodate relatively large diameter road wheels and high deflection spring gear yet provide adequate gangways through the locomotive indicated that a new concept in design of the superstructure was essential.

As a result the frame is designed as an integral stress bearing structure, the base being of shallow cellular construction and all body framing members of tubular section. This form of construction meets the essential requirements, i.e.,

(*a*) Resist static and dynamic vertical and longitudinal loads.

(*b*) Accommodate a 200 ton compressive end load within the elastic limit of all materials.

(*c*) Provide gangways through the locomotive not less than 5 ft. 10 in. high.

To achieve the result, resort has been made to special steels, aluminium alloys and glass-fibre construction. Steel castings have been avoided as much as possible and fabrication by welding is largely employed throughout.

The superstructure and bogie frames have been completely stress analysed and will be subjected to strain gauge tests in accordance with the loading conditions imposed.

6.1 *Bogies*

The bogies, see fig.9, are designed for low maintenance; practically all the operating gear such as primary and secondary springs, axleboxes, traction links, hydraulic dampers, brake cylinders and slack adjusters are externally arranged for ease of inspection. Brake blocks and cotters are directly accessible.

To minimise weight transfer during traction the bogie pivot and traction links are located at axle level.

Special care has been given in the design to promote good riding of the locomotive by provision of long range spring gear, swing motion bolsters, and close guiding of wheel and axle sets. The superstructure is metallically insulated from the bogies by means of rubber at the centre pivots, side-bearers and traction links.

To obviate any tendency to 'hunting' of the bogies on the track at high speed a proportion of the vertical load from the superstructure is transmitted through the side-bearers which incorporate coil springs with a pre-determined setting. Periodic movements of the swing motion bolsters are restrained by the fitting of transverse hydraulic dampers.

In place of the usual spring planks associated with swing motion bolsters, transverse anchor links are fitted between the bolster beam and spring beam. This arrangement is very much lighter than the orthodox beam yet has the advantage that it does not induce compound stresses in the bolster springs when the bolster moves transversely.

To obviate normal friction plates in the swing bolster, the longitudinal forces from traction thrust and braking are transmitted by two links fitted between the bogie frame and bolster. To cater for the compounded movements the links are fitted with Spherilastic rubber bonded bushes at each end.

The bogie side frames, transoms and headstocks are of fabricated box section construction to provide high bending and torsional stiffness. The bogie frames are stress-relieved.

The axleboxes are fitted with S.K.F. single-row self-aligning spherical bearings. A short equalising spring beam is pin jointed to the underside of the axlebox and the primary coil springs rest in cups attached to the beam. Hydraulic dampers are fitted inside the springs. The primary and secondary springs are manufactured from centreless ground silico-manganese steel bars which are crack detected before and after coiling and finished by shot blasting and zinc coating.

The wheels are 48 in. diameter on tread, the wheel centres being steel castings with elliptical shaped spokes and triangulated hubs and rims. The wheel sets are statically and dynamically balanced. All wheels are fitted with clasp type brakes. An individual brake cylinder is provided at each wheel and operates on the blocks by a system of levers and rods. A mechanically operated automatic slack adjuster is incorporated which permits full brake shoe wear without intermediate adjustment.

Earthing brushes are fitted on one end of each axle with connections to the bogie frame and superstructure.

6.2 *Frame and Body Structure*

The frame and body is designed and fabricated as a unit stress bearing structure in Cor-Ten steel, see fig.10. The base is of shallow cellular construction with close spaced light gauge longitudinal and transverse members interlocked with each other. The structure is plated top and bottom to form a closed cell; high vertical, longitudinal and torsional rigidity is thus obtained. To obviate corrosion the interior of the structure is metal sprayed and adequately drained and vented.

The body side frames are of girder design. The vertical pillars are rectangular tubes and the cantrail a compound closed section. Combined with the base structure, cabs and bulkheads a comprehensive structural member of immense strength, yet light in weight, is achieved commensurate with the loads imposed.

As the roof can be completely open between cab bulkheads – to permit installation of the electrical equipment – no permanent structural ties can be provided, therefore to provide maximum torsional rigidity and prevent flexing of the body sides the side frames have both interior and exterior skins.

The exterior of the locomotive is made as flush as possible, devoid of mouldings, etc. to improve appearance but is also an aid in obviating corrosion.

The aim has been to provide a structure which should be relatively trouble free throughout the life of the locomotive.

The drivers cabs are generally as described in Paper 3 – see fig.11.

Resin bonded glass-fibre construction is used for the entire driving desk and for the side-entrance doors, cable ducts, covers, etc. Considerable weight saving has resulted from this construction, in addition, the general appearance is improved.

6.3 *Brake System*

The brake system is generally described in Paper 3.

These locomotives are equipped with the 'Metcalfe-Oerlikon' vacuum controlled air brake and anti-wheel slip apparatus.

7. Conclusion

The completion of these locomotives shows that it is feasible to build, within the difficult loading gauge of British Railways, dual-voltage 3,000 h.p. locomotives of low weight, whilst still retaining the ample margins and robust construction necessary for reliable operation.

SUMMARY

This paper describes the A.C. locomotives manufactured by the English Electric Group of Companies.

The locomotives were designed to meet the performances specified by the British Transport Commission. They are of the Bo-Bo wheel arrangement and have 2 driving cabs; some are geared for 100 m.p.h. and some for 80 m.p.h. maximum speed and all have a continuous rating of 2,950 h.p. on either 25 kV or 6·25 kV supply, and weigh 73 tons.

Low voltage tap-changing is used thus enabling the dual supply voltage to be catered for by series or parallel connection of four primary windings. The transformer, as well as the D.C. smoothing and tap-changing reactors, is oil cooled.

The tap-changer comprises cam-operated tapping selector contacts and a winding grouping switch but all the current making and breaking is performed by separate electro-pneumatic contactors. A total of 40 economical running notches is provided.

The 8 rectifiers are of the water-cooled ignitron type and are connected in 2 three-wire bridge circuits. The traction motors, which are 4-pole conventional D.C. machines each having its own smoothing reactor, are bogie mounted and drive through Brown Boveri-SLM flexible drive.

Compressors and exhausters are driven by D.C. motors fed from a generator coupled to the Arno convertor but all other auxiliary motors are simple 3-phase induction motors.

The locomotive frame is designed and fabricated as a single stress-bearing structure. The underframe is of cellular construction and is plated top and bottom. The body side frames are made up of tubular sections and are panelled inside and outside. 'Cor-Ten' steel is used for all frame and body members and panels.

The bogie frames, transoms and headstocks are of welded box sections and are stress relieved. Compensating beams carry the primary coil springs and hydraulic dampers. Swing links are fitted and hydraulic dampers control transverse movements; the secondary springs are of the coil type. The total combined static deflection is 6 in. Rubber-jointed links are used to transmit tractive forces and a rubber centre pivot is provided. The bogies are designed for low maintenance and easy access to operating gear.

The weights of electrical and mechanical parts are 37 and 36 tons respectively.

RÉSUMÉ

Cet exposé décrit les locomotives à courant alternatif construites par le Groupe de Sociétés English Electric.

Ces locomotives ont été construites pour satisfaire les performances specifiées par la British Transport Commission. Elles sont du type Bo-Bo et ont deux cabines de conduite. Certaines sont equipées d'engrenages pour 100 m.p.h., vitesse maximum, d'autres pour 80 m.p.h. Toutes ont, au régime continu, une puissance de 2950 h.p. soit à la tension de 25 kV, soit à 6,25 kV et pèsent 73 tons.

Le réglage de la tension appliquée aux moteurs s'effectue par changement de prises sur le secondaire du transformateur, permettant ainsi le fonctionnement de la locomotive sous deux tensions différentes de caténaire par le couplage en série ou en parallèle des quatre sections de l'enroulement primaire. Le transformateur, ainsi que les selfs de lissage et les réactances de transition sont à refroidissement par huile.

Le graduateur comprend des contacteurs à commande par cames et un commutateur adapté pour ajouter les deux sections fixes en série avec les deux sections de réglage, mais la fermeture et la coupure du courant sont faites par des contacteurs électro-pneumatiques separés. Un total de 40 crans de marche économique est prévu.

Les 8 redresseurs sont du type ignitrons à refroidissement par eau et sont connectés en deux circuits de Graetz avec connection d'équilibre.

Les moteurs de traction qui sont des machines à courant continu conventionnelles à 4 pôles, chacun ayant sa propre self de lissage, sont montés sur les bogies et entraînent par l'intermédiaire d'une commande élastique Brown-Boveri-SLM.

Les compresseurs et les aspirateurs sont entraînés par des moteurs à courant continu alimentés par une génératrice accouplée à un convertisseur Arno, mais tous les autres moteurs auxiliaires sont des moteurs asynchrones triphasés ordinaires.

Le châssis et la caisse de la locomotive sont conçus et fabriqués comme une construction intégrale et monocoque. Le sous-châssis comprend une ossature de construction cellulaire et est recouvert de tôles au-dessus et au-dessous. L'ossature de la caisse est formée par des sections tubulaires et a un panneautage intérieur et extérieur. L'acier " Cor-Ten " est employé pour toute l'ossature et tous les panneaux du châssis et de la caisse.

Les châssis, les longerons et les traverses des bogies sont des pièces en caisson soudées et à efforts equilibrés. Des balanciers compensateurs supportent les ressorts helicoïdaux primaires et les amortisseurs hydrauliques. Des bielles de suspension sont installées et des amortisseurs hydrauliques contrôlent les mouvements transversaux; les ressorts secondaires sont du type helicoïdal. La flexion statique combinée totale est de 6 in. Des coulisses, dont les raccords sont en caoutchouc, sont employées pour transmettre les efforts de traction et le caoutchouc est aussi employé au pivot central. Les bogies sont construits de façon à réduire l'entretien et permettre un accès facile aux pièces mouvantes.

Les poids de la partie mécanique et de la partie éléctrique sont respectivement de 37 et de 36 tons.

ZUSAMMENFASSUNG

Dieser Vortrag beschreibt die von der " English Electric Group of Companies " hergestellten Wechselstromlokomotiven. Die Lokomotiven wurden nach einer Spezifikation der " British Transport Commission" gebaut. Die Lokomotiven sind mit 4 Achsen in der Anordnung Bo-Bo und mit zwei Führerkabinen ausgerüstet. Bei einigen ist das Übersetzungsverhältnis für eine Höchstgeschwindigkeit von 100 m.p.h. – und bei anderen für 80 m.p.h. gewählt. Alle Lokomotiven haben eine Dauerleistung von 2950 h.p. bei einer Fahrdrahtspannung von 25 kV oder 6,25 kV und wiegen 73 tons.

Die Motorspannung ist durch Niederspannungssteuerung des Transformators geregelt. Es ist deshalb möglich vier Primärwicklungen in Serie für 25 kV oder in Parallel für 6,25 kV zu schalten.

Der Stufenschalter besteht aus nockenbetätigten Wählerkontakten und einem Wicklungsgruppenschalter, der Strom wird von einzelnen elektropneumatischen Schützen ein- und abgeschaltet. 40 wirtschaftliche Fahrgeschwindigkeitsstufen sind vorgesehen.

Die 8 Gleichrichter sind wassergekühlte Ignitrongeräte und bilden 2 Dreidrahtbrückenkreise. Die Fahrmotoren sind Vierpolmotoren der üblichen Bauart, jede Maschine ist mit ihrer eigenen Glättungsdrossel versehen. Die Motoren sind auf die Drehgestelle

montiert und treiben die Räder durch eine elastische Kupplung der Brown Boveri SLM.

Die Kompressoren und Sauglüfter werden von Gleichstrommotoren angetrieben, der Strom wird von einem mit dem Arno Umformer gekuppelten Generator geliefert; alle anderen Hilfsmotoren sind einfache Drehstrom-Asynchronmotoren.

Der Rahmen der Lokomotive ist als einfache, spannungstragende Struktur gebaut und zusammengeschweisst. Der zellenartige Unterrahmen ist oben und unten mit Platten versehen. Die Seitenrahmen des Hauptkörpers sind aus Röhren hergestellt und innen und aussen mit Platten abgedeckt. Alle Stangen und Bleche des Rahmens und des Hauptkörpers sind aus " Cor-Ten "-Stahl hergestellt. Die Drehgestellrahmen, Querverbindungen und Vordertraversen bestehen aus geschweissten Kastenprofilen und sind entspannungsgeglüht. Kompensationsarme tragen die primären Schraubenfedern und hydraulischen Dämpfer. Schwingkulissen sind vorgesehen und hydraulische Dämpfer steuern die Bewegung des Rahmens in der Seitenrichtung, die Sekundärfedern sind ebenfalls Schraubenfedern. Die gesamte statische Ausbiegung beträgt 6 in. Die Zugkraft wird durch Glieder mit Gummigelenken übertragen, die Lokomotiven haben ebenfalls einen zentralen, mit Gummi gepolsterten Zapfen. Die Drehgestelle sind so konstruiert, dass sie wenig Instandhaltungsarbeiten verlangen und leichten Zutritt zum Laufwerk gewähren.

Das Gewicht des elektrischen bzw. mechanischen Teiles beträgt 37 bzw. 36 tons.

RESÚMEN

Esta memoria describe las locomotoras de corriente alterna construídas por el Grupo de Compañías English Electric.

Las locomotoras fueron diseñadas para satisfacer el rendimiento y funcionamiento especificados por la Comisión Británica de Transportes (British Transport Commission). Son de disposición de ruedas Bo-Bo, y tienen dos cabinas de conduccion; algunas locomotoras están engranadas para una velocidad máxima de 100 m.p.h. y otras para una velocidad máxima de 80 m.p.h., y todas son de una clasificación de funcionamiento continuo de 2950 H.P. con el suministro de 25 kV o de 6,25 kV; y son de un peso de 73 tons.

Se emplea el cambio de toma de voltaje bajo, permitiendo en esta forma el que pueda atenderse al voltaje del suministro dual valiéndose de una conexión paralela o en serie de cuatro arrollamientos primarios. El transformador, así como los reactores suavizadores de corriente continua y reactores de cambio de toma usan aceite por el enfriamiento.

El cambiador de tomas comprende contactos selectores de toma de accionamiento de leva y un interruptor agrupador de arrollamiento, pero todos los cambios son hechos por contactores electroneumáticos. Se lleva provisto un total de 40 muescas de marcha (para el funcionamiento mas eficiente).

Los 8 rectificadores de tipo ignitrón usan el enfriamiento por agua y están conectados en dos circuitos de puente de tres alambres. Los motores de tracción, los cuales son maquinas de corriente continua convencionales de 4 polos, tienen su propio reactor suavizador individual; son de montura de bogie y transmiten el mando a través de un mando flexible Brown-Boveri-SLM.

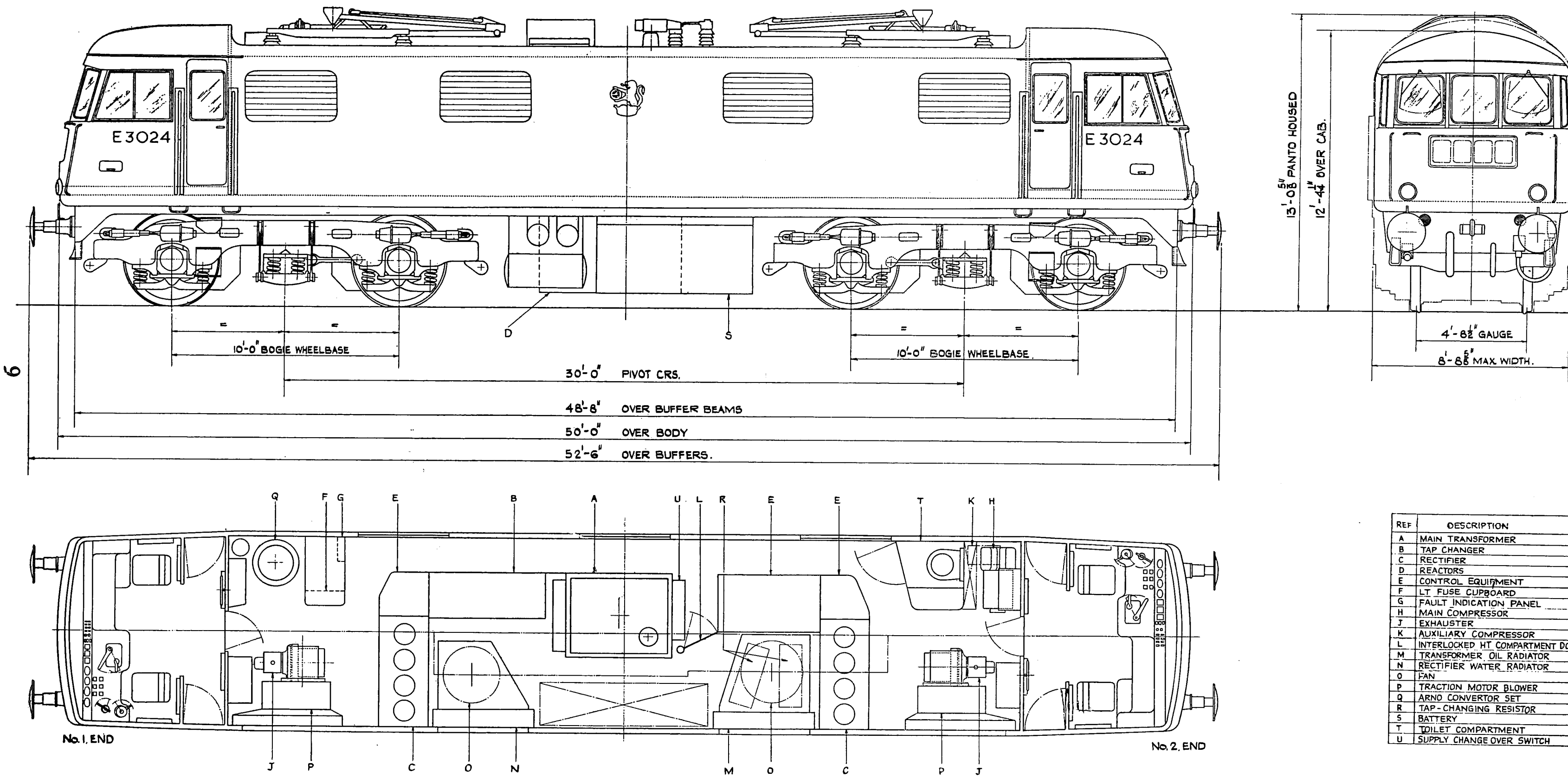
Los compresores y bombas de vacio son mandados por motores de corriente continua, alimentados por un génerador acoplado al convertidor Arno, pero todos los demás motores auxiliares son de inducción trifásicos sencillos.

El bastidor de la locomotora ha sido diseñado y fabricado de piezas, como una estructura entera y completa. El bastidor es de construcción celular y está cubierto con chapas en las partes supiores y inferiores. Los costados del cuerpo son hechos de perfiles tubulares y están cubiertos con paneles en las partes interiores y exteriores. Se emplea acero " Cor-Ten " para todos los miembros y paneles del bastidor y del cuerpo.

Los cuerpo de bogie, travesaños y las cabeceras son en su totalidad secciones de caja soldadas y han sido recocidas. Balancines llevan los resortes espirales y los amortiguadores hidraulicos (de la suspension primaria). Se llevan instaladas articulaciones oscilantes y los amortiguadores hidráulicos regulan los movimientos transversales; los resortes de la suspension secundarias son de tipo espiral. La flexión estatica combinada total es de 6 in. Se emplean articulaciones de unión de caucho en las barras de tracción y el pivote central tiene un revistimiento de caucho. Los bogies han sido diseñados para asegurar un costo de mantenimiento bajo y un acceso fácil a la transmision.

Los pesos de las piezas electricas y mecanicas son de 37 y 36 tons respectivamente.

Fig.1 Locomotive on test track at works (Vulcan foundry). Nos.E.3024/35, E.3303/5



REF	DESCRIPTION
A	MAIN TRANSFORMER
B	TAP CHANGER
C	RECTIFIER
D	REACTORS
E	CONTROL EQUIPMENT
F	LT FUSE CUPBOARD
G	FAULT INDICATION PANEL
H	MAIN COMPRESSOR
J	EXHAUSTER
K	AUXILIARY COMPRESSOR
L	INTERLOCKED HT COMPARTMENT DOOR
M	TRANSFORMER OIL RADIATOR
N	RECTIFIER WATER RADIATOR
O	FAN
P	TRACTION MOTOR BLOWER
Q	ARNO CONVERTOR SET
R	TAP-CHANGING RESISTOR
S	BATTERY
T	TOILET COMPARTMENT
U	SUPPLY CHANGE OVER SWITCH

Fig.2 General arrangement. Nos.E.3024/35, E.3303/5

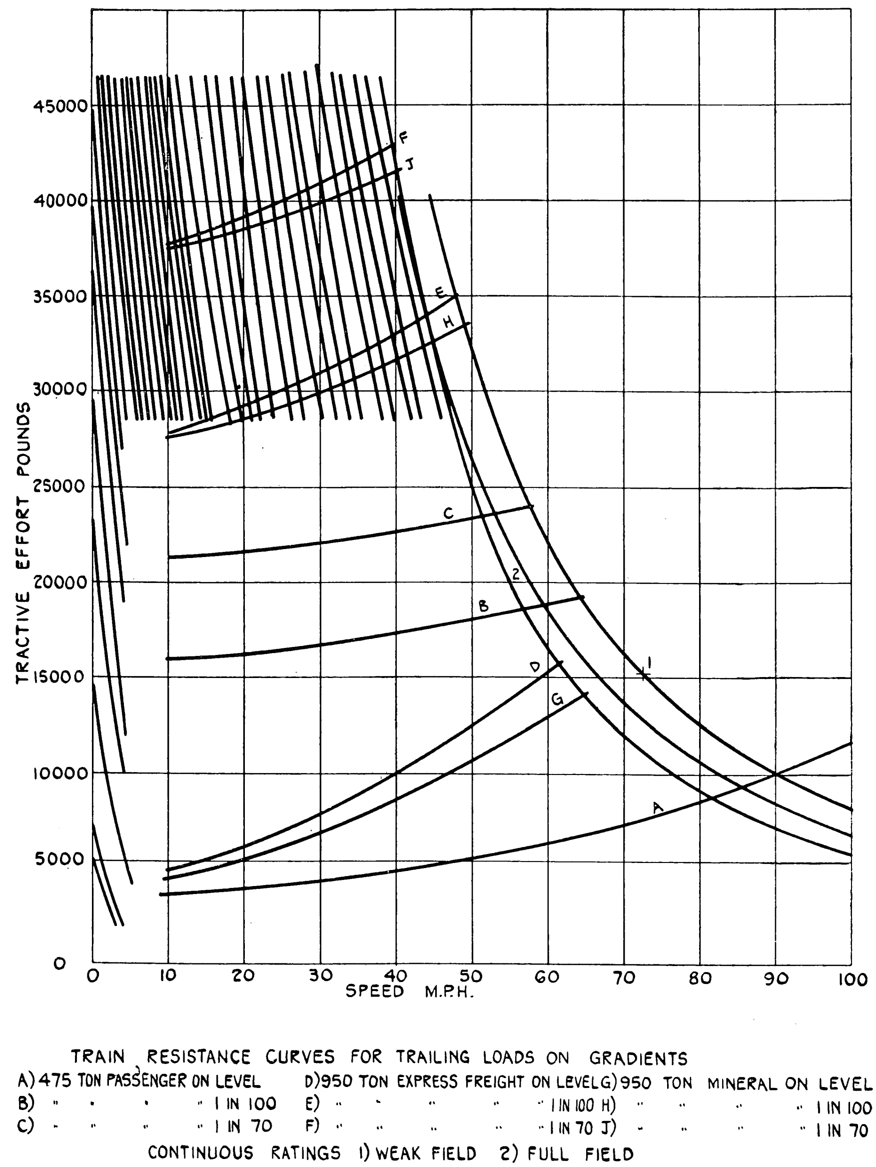
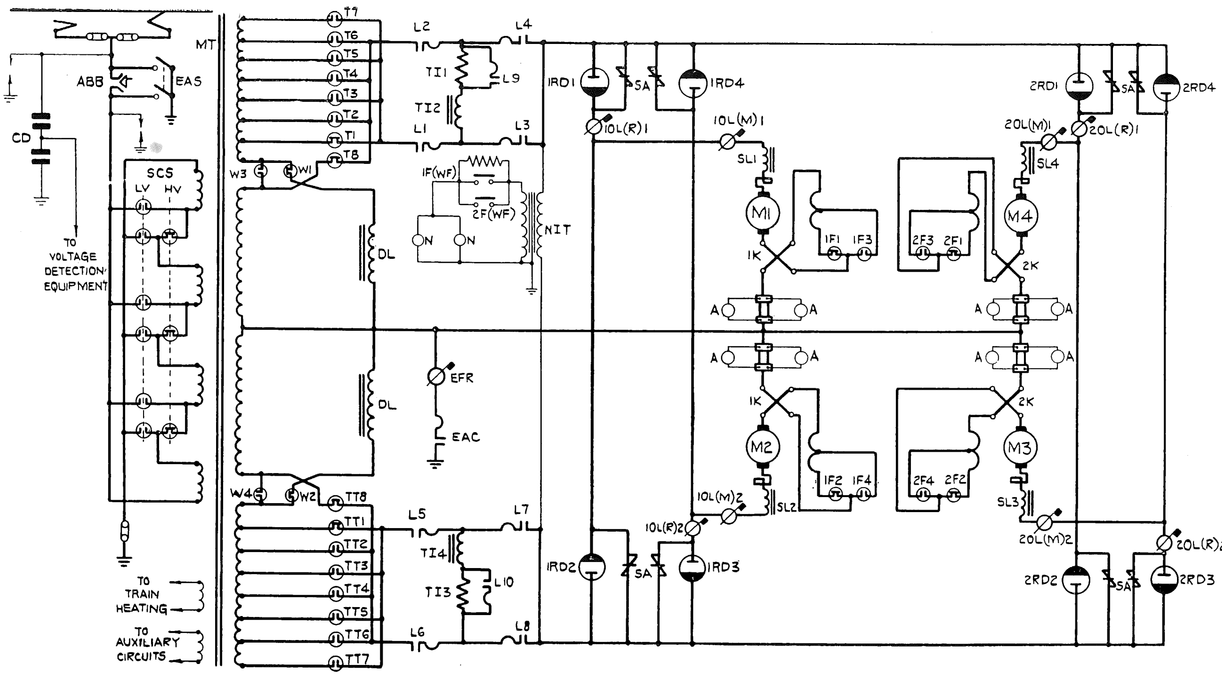
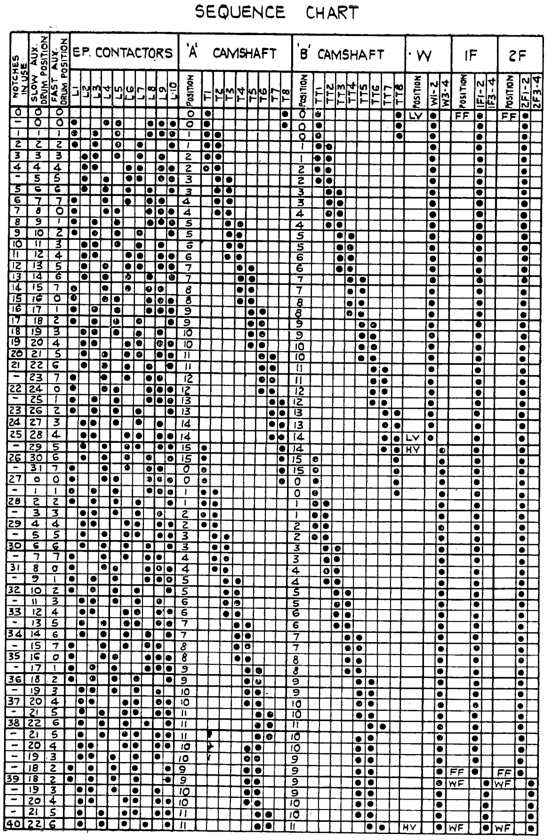


Fig.3 Performance curves for B.T.C. A.C. mixed traffic 'A' ocomotive based on 22·5 kV line voltage and half worn wheels. Nos.E.3024/35, E.3303/5

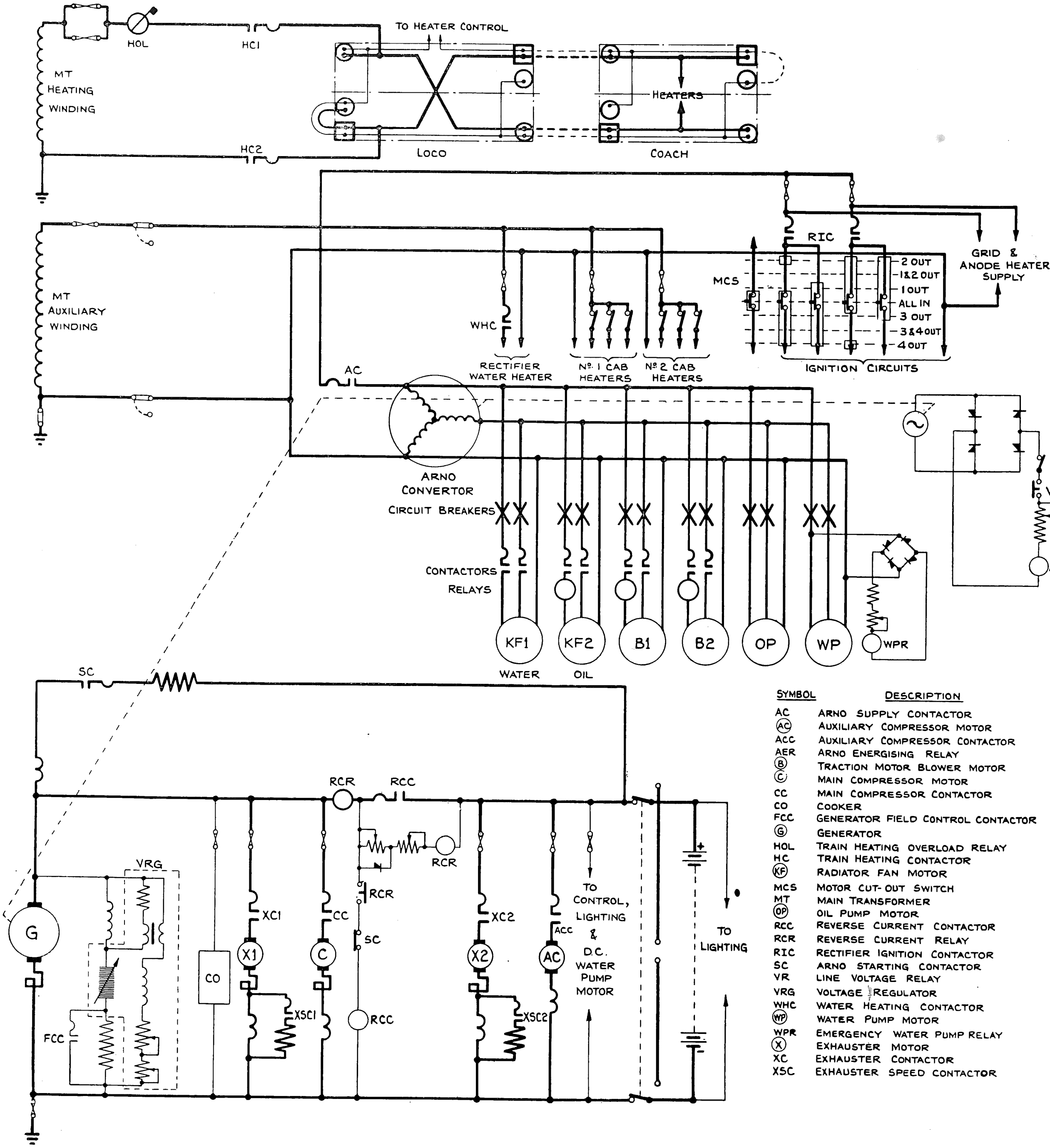


SEQUENCE CHART



SYMBOL	DESCRIPTION
A	AMMETER
ABB	AIR-BLAST CIRCUIT BREAKER
CD	CAPACITOR DIVIDER
DL	DROPPING REACTOR
EAC	EARTH CONTACTOR
EAS	EARTHING SWITCH
EFR	EARTH FAULT RELAY
F	FIELD TAP SWITCH
K	REVERSER
L	LINE CONTACTOR
M	TRACTION MOTOR
MT	MAIN TRANSFORMER
N	NOTCH INDICATOR
NIT	NOTCH INDICATOR TRANSFORMER
OL (M)	MOTOR OVERLOAD RELAY
OL (R)	RECTIFIER OVERLOAD RELAY
RD	MAIN RECTIFIER
SA	SURGE ARRESTOR
SCS	SUPPLY CHANGEOVER SWITCH
SL	SMOOTHING REACTOR
T, TT	TAP-CHANGING SELECTORS
TI1, 3	TAP-CHANGING RESISTOR
TI2, 4	TAP-CHANGING REACTOR
W	WINDING GROUPING SWITCH

Fig.4 Power schematic. Nos.E.3024/35, E.3303/5



SYMBOL	DESCRIPTION
AC	ARNO SUPPLY CONTACTOR
(AC)	AUXILIARY COMPRESSOR MOTOR
ACC	AUXILIARY COMPRESSOR CONTACTOR
AER	ARNO ENERGISING RELAY
(B)	TRACTION MOTOR BLOWER MOTOR
(C)	MAIN COMPRESSOR MOTOR
CC	MAIN COMPRESSOR CONTACTOR
CO	COOKER
FCC	GENERATOR FIELD CONTROL CONTACTOR
(G)	GENERATOR
HOL	TRAIN HEATING OVERLOAD RELAY
HC	TRAIN HEATING CONTACTOR
(KF)	RADIATOR FAN MOTOR
MCS	MOTOR CUT-OUT SWITCH
MT	MAIN TRANSFORMER
(OP)	OIL PUMP MOTOR
RCC	REVERSE CURRENT CONTACTOR
RCR	REVERSE CURRENT RELAY
RIC	RECTIFIER IGNITION CONTACTOR
SC	ARNO STARTING CONTACTOR
VR	LINE VOLTAGE RELAY
VRG	VOLTAGE REGULATOR
WHC	WATER HEATING CONTACTOR
(WP)	WATER PUMP MOTOR
WPR	EMERGENCY WATER PUMP RELAY
(X)	EXHAUSTER MOTOR
XC	EXHAUSTER CONTACTOR
XSC	EXHAUSTER SPEED CONTACTOR

Fig.5 Auxiliary schematic. Nos.E.3024/35, E.3303/5

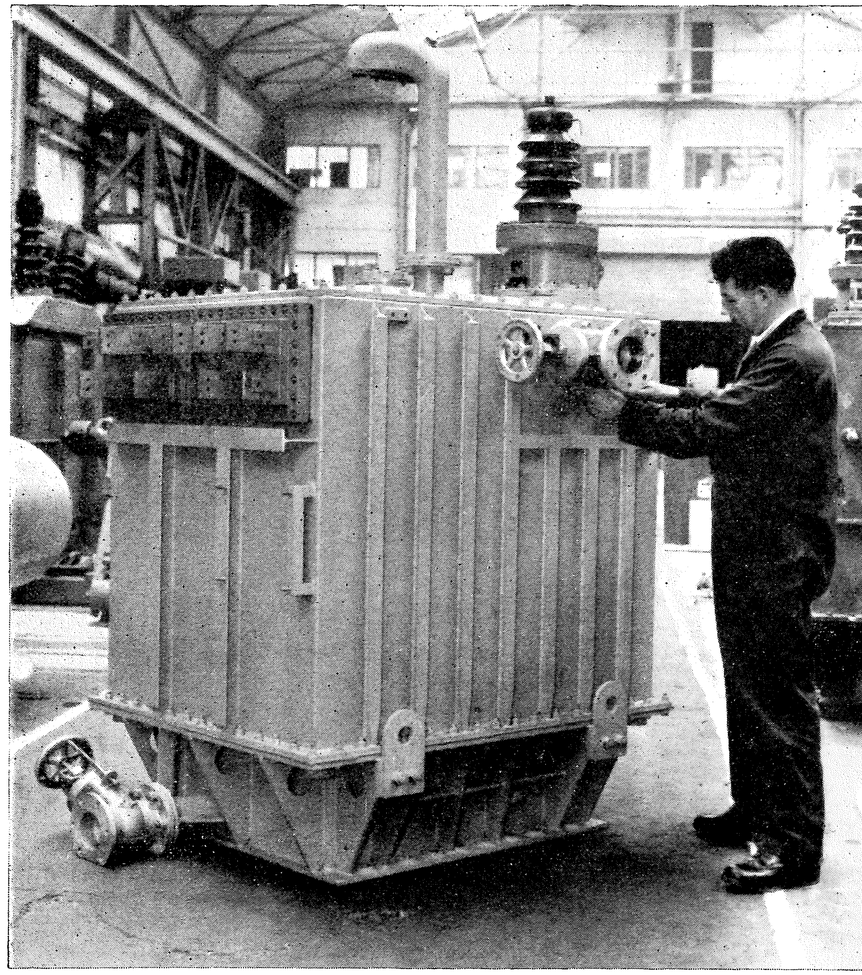


Fig.6 Main transformer L.V. terminals at L.H. end. Nos.E.3024/35, E.3303/5

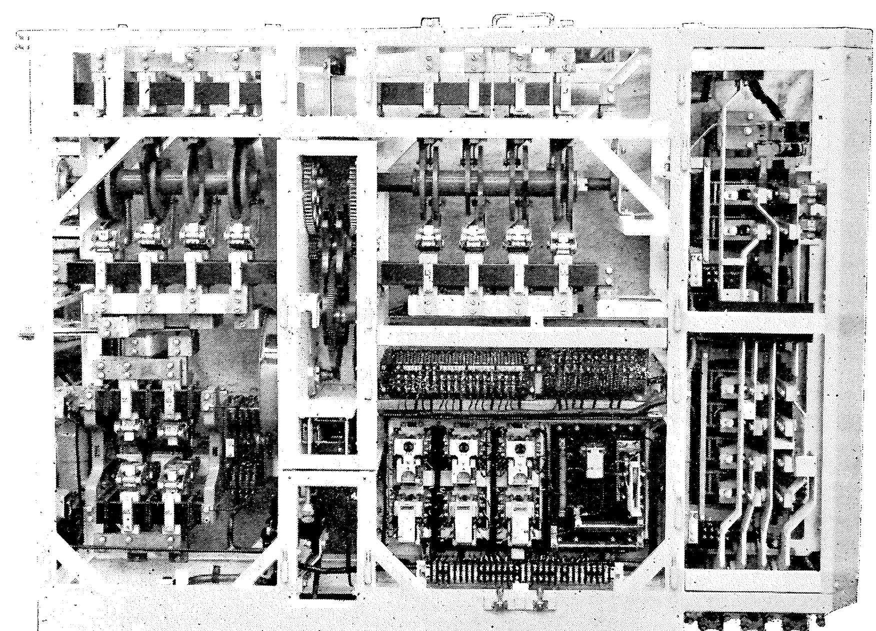
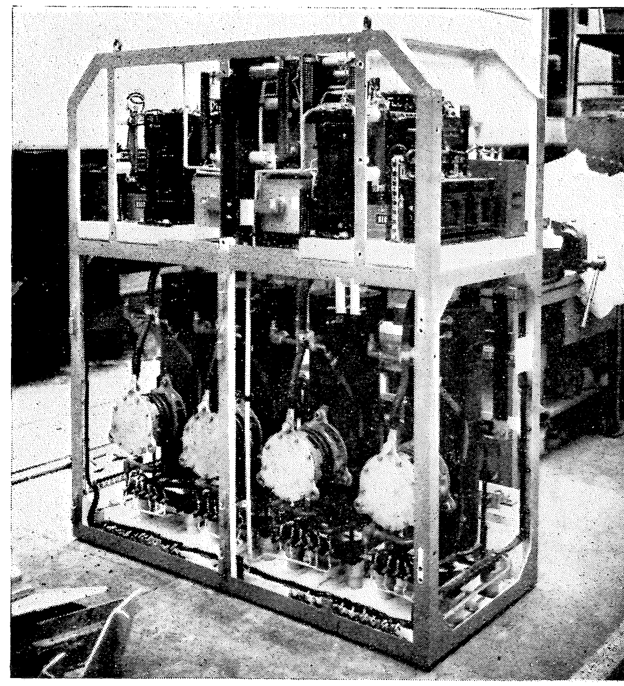
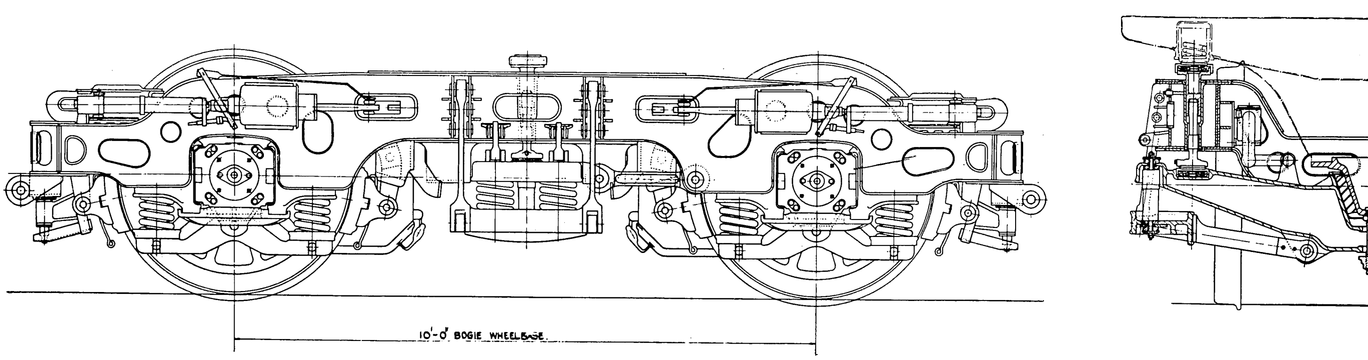


Fig.7 Tapchanger (covers removed) control equipment at R.H. end. Nos.E.3024/35, E.3303/5

Fig.8 Rectifier frame. Surge Arrestors in front of ignitions. Firing gear above. Nos.E.3024/35, E.3303/5





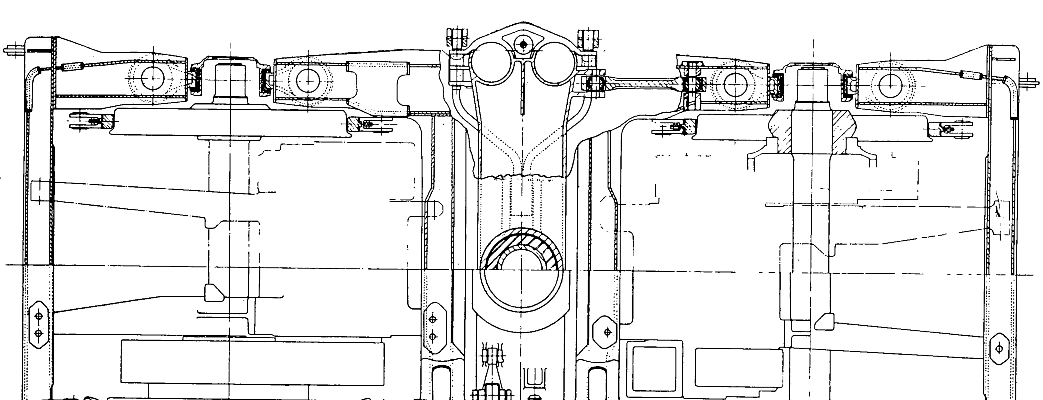


Fig.9 Bogie. Nos.E.3024/35, E.3303/5

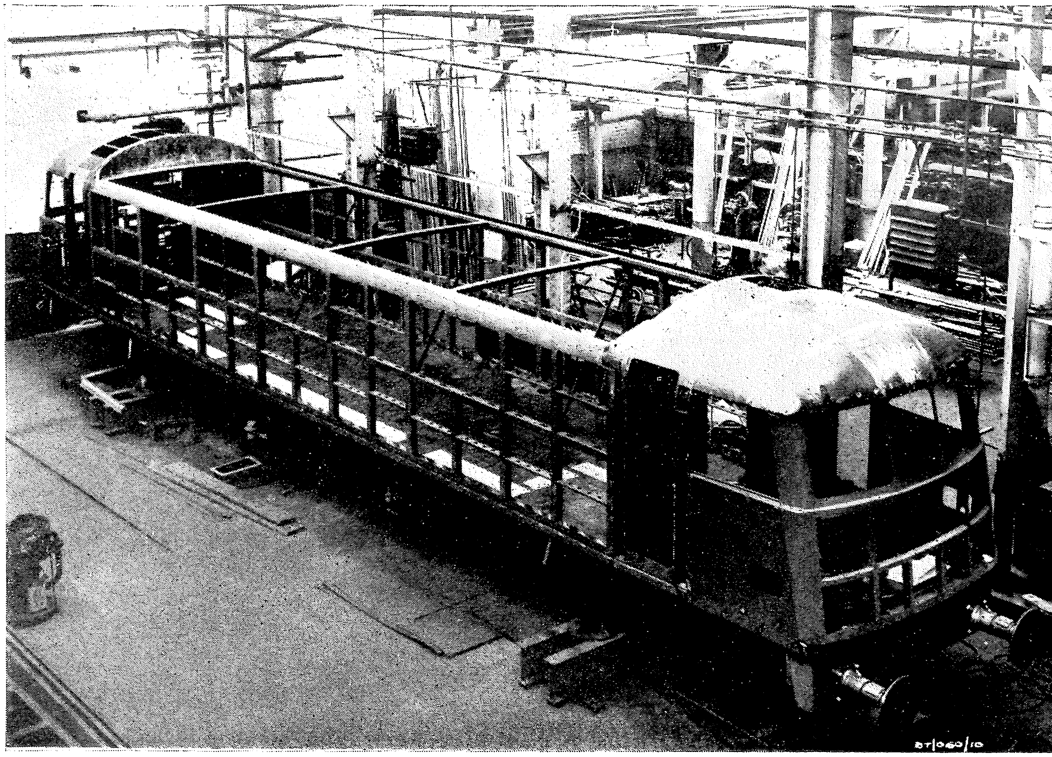


Fig.10 Superstructure during building. Nos.E.3024/35, E.3303/5

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