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Paper 15

Locomotives: Nos.E3001/23, E3301/2 (A.E.I. Rugby)

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1. Introduction

A.E.I. (Rugby) Ltd (formerly The British Thomson-Houston Co., Ltd), received an order from The British Transport Commission for 25 complete 25 kV A.C. single-phase rectifier locomotives, and also for 40 sets of power equipments of the same type for installation in mechanical parts to be built in the British Railways workshops.

The 25 complete locomotives are equipped with rectifiers of the well-proved pumpless steel-tank, mercury-arc type, but the 40 sets of power equipments will incorporate semi-conductor rectifiers and these are fully described in Paper 19.

Locomotives E.3001/23 are Express Passenger Locomotives (Type A) and are designed to meet the duties described in Paper 3. Locomotives E.3301/3302 are Mixed Traffic Locomotives (Type B) and differ only in the traction motor gear ratio.

The manufacture of the mechanical parts was entrusted to the Birmingham Railway Carriage & Wagon Co., Ltd, and it was decided to take advantage of Continental experience with flexible traction motor drives, and rubber suspension on high speed locomotives, and to develop these features in a bogie specially designed to suit a Bo-Bo locomotive of over 3,000 h.p.

2. Leading Particulars

The leading particulars of these locomotives are summarised in the following table:

Total weight	80 tons
Maximum axle load	20 tons
Weight of electrical equipment (including drive)	39·6 tons
Weight of two bogies (excluding motors and drive)	21·0 tons
Weight of underframe and body	19·4 tons
Length over buffers	56′ 6″
Bogie wheelbase	10′ 9″
Bogie Centres	31′ 6″
Wheel diameter	48″
Gear ratio	29:76
Maximum service speed	100 m.p.h.
Mean value of accelerating tractive effort	48,000 lb.

Continuous ratings:	*Full Field*	*Weak Field*
Tractive effort	20,000 lb.	17,000 lb.
Speed	60 m.p.h.	71 m.p.h.
Power	3,200 h.p.	3,200 h.p.

NOTE: The performance figures relate to wheel treads, half-worn wheels and supply voltage 22·5 kV or 5·63 kV.

The performance figures relate to Type A locos: in the case of Type B all speeds are less in the ratio 100/80 and the tractive efforts correspondingly higher.

The locomotive characteristic is shown on fig.1 including notching at the accelerating current.

The general appearance of the locomotives is illustrated by fig.2 and the layout, fig.3.

3. Description of Circuits

3.1 *The Power Circuit* (*fig.*4)

The main transformer primary winding is divided into four sections which are connected either in series or parallel to suit the 25 kV or 6·25 kV condition. This arrangement, which only suits low tension tap changing, gives maximum economy of primary copper and maximum protection against the effects of line surges compared with voltage changeover by a transformer tap.

The secondary of the transformer has three separate power windings. Two windings each giving half the rectifier phase voltage are each connected in series with tappings at half rectifier phase voltage from a centre tapped auto-transformer. This auto-transformer is energised by the third winding on the main transformer at a voltage of approximately 2·5 kV.

The 2·5 kV winding has tappings to give nine equal sections so that the voltage applied to the auto-transformer can be

varied from zero to maximum value via the tap change contactors and reactor. The voltage across the auto-transformer due to this tapped winding can be reversed by the contactors AA and BB, so that the fixed voltage secondary windings on the main transformer can be bucked or boosted by the tapped sections of the auto-transformer. In going from maximum bucking voltage through zero to maximum boosting voltage, the rectifier phase voltage is varied, from minimum to maximum in 37 steps using only 10 tappings and 20 contactors.

This arrangement was chosen in order to have a free choice of tap changing voltage, and to economise in the number of transformer taps and contactors required. 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, connected in parallel for bi-phase operation, so that each tank has three anodes carrying current in each half cycle.

Reactors ensure equal sharing of the current between tanks and between individual anodes. The D.C. output is fed to the four series traction motors connected in parallel to give the best conditions for adhesion and smoothing chokes are included in the D.C. circuit. Separate motor contactors are not included as motor overload protection operates on the high speed line breakers L1 and L2, which are included to give rectifier back-fire protection, and are also used as contactors for switching on and off the supply to the rectifiers.

An off-load motor isolating switch is provided to cut out motors if required, and a 3-position air-operated reverser, an open position being required for rectifier heating. Field shunt contactors provide two stages of field weakening, and the motors always operate with a field divert resistance in circuit to improve the commutation conditions with 100-cycle ripple.

The shorting switch (RSC) across the rectifier output is used to warm up the rectifiers under low voltage before applying full power if the tank temperature is below the acceptable minimum.

While single anode rectifiers in bridge connection are more economical from the point of view of the transformer secondary copper, the use of three fully developed multi-anode tanks which are suitable for bi-phase connection only, proved to be the most economical arrangement for the power of these particular locomotives.

3.2 *The Auxiliary Circuits* (*fig.*5)

The general principles are as follows:

An 826V winding on the main transformer, which supplies the train heating load and also space heaters for warming up the rectifier compartments when required, also energises an auto-transformer tapped at 139V to supply:

(*a*) The rectifier ignition and excitation circuits.

(*b*) The rectifier anode heaters.

(*c*) The cab heaters

(*d*) The various cooling fans and transformer oil circulating pump, which are driven by single phase capacitor start and run motors.

(*e*) The No.1 exhauster, main air compressor and certain coils of protection gear, all operating on D.C. through individual rectifiers.

(*f*) The 110V D.C. system and battery which is charged by means of a static voltage regulating system, which will hold the voltage within + or — 2 V of the pre-set value, irrespective of the normal maximum line variations.

The 110V D.C. system supplies:

(*a*) The power selection circuits which operate the transformer primary series parallel switching under the influence of the overhead line potential and the track magnets.

(*b*) The power control circuits which operate the rectifier pre-heating, the closing and opening of the air blast circuit breaker, the line breakers and the notching of the tap change camshaft, by means of the master controllers.

(*c*) The No.2 exhauster and the auxiliary air compressor.

(*d*) The various contactors and relays controlling rectifier excitations, fans, blowers, pumps, heaters and lamp circuits.

4. Description of Electrical Apparatus

4.1 *Roof mounted H.T. Equipment*

This comprises two standard pantographs, the air blast circuit breaker and a potential measuring device for the 25/6·25 kV changeover. This consists of a current transformer fed from a bushing type capacitor and resistance connected direct to the pantograph. The C.T. burden consists of three voltage relays supplied from a rectifier bridge. The combination of relays picked up by the line voltage operates the magnet valves of the air engine which throws the transformer primary series/parallel switch with the air-blast breaker open.

4.2 *The Main Transformer* (*fig.*6)

The main transformer unit consists of the power circuit transformers which include the heating circuit winding and the series/parallel primary switch, all mounted in one tank arranged for oil cooling by means of forced circulation through two radiator panels mounted under the roof. Cooling air is drawn in through the side of the locomotive, and discharged upwards through the radiators by means of two axial flow fans. The transformer tank contains the minimum of oil to reduce weight and the tank itself consists of a strong fabricated cradle with light steel wrapper plates and cover, the cradle is carried in the locomotive underframe on four rubber bushed trunnion bearings.

The 826/139V auxiliary auto-transformer together with the rectifier load sharing reactors and the tap change reactor are separate air cooled units, in order to keep the quantity of oil necessary as small as possible.

The kVA ratings of the various transformer winding at 22·5 kV input are as follows:

Primary winding	22·5 kV	4,000 kVA
Secondary fixed voltage windings (2) each	646V	1,345 kVA
Secondary tapped winding	2,093V	1,730 kVA
Secondary heater winding	826V	390 kVA
Auto-transformer	2×587V	2,440 kVA

4.3 *The Tap Changing Equipment and Control Unit (fig.7)*

The tap changing equipment and the bulk of the control gear are mounted together as a single unit in a fabricated steel frame as illustrated in fig.7.

The tap change unit itself consists of two rows of cam-operated contactors, one above and one below the camshaft. De-ion type arc chutes are fitted. The camshaft is built up from moulded cams on a steel shaft and is driven by a D.C. motor through reduction gearing and a geneva mechanism.

The distance the camshaft can travel when taking each notch under the direction of the master controller is governed by finger type 'range interlocks' operated by auxiliary cams. The driving motor is dynamically braked to a standstill.

The transition contactors which arrange for the tapped winding to buck or boost the fixed voltage winding are also cam-operated. The cams operating these are carried on the main camshaft on concentric needle roller bearings and are moved by double acting air cylinders through levers and are under the control of magnet valves.

The relay panels and contactors and fuses controlling auxiliary motors are mounted alongside the camshaft on the same frame and are accessible from the corridor by removing fibre-glass panels. Also in the same frame and below the camshaft are mounted the hand-operated motor selection switch which is interlocked by the driver's master key and also the air-operated reverser, overload relay and field shunt contactors. Control leads are brought to accessible terminal bars so that the unit can be handled as a complete wired-up unit.

4.4 *The Rectifiers (fig.8)*

Each of the three mercury arc rectifiers which operate in parallel consists of a 6-anode air cooled pumpless steel tank unit of long-established design, but with modified cathode to minimise splashing of the mercury pool under traction conditions, and with an ignition device suitable for frequent operation. The anode heaters and anode reactors are mounted on top of the rectifiers.

The three rectifiers are mounted side by side in an airtight compartment and are carried on resilient mountings arranged close to their centres of gravity. To control the rectifier temperature, air is drawn in through the louvres in the side of the locomotive by three axial flow fans in a plenum chamber, and discharged under pressure, into separate ducts to each rectifier, passing over the cathodes and cooling fins and then being discharged through louvres in the roof traps over the rectifier compartment. The bulkhead between the plenum chamber and the space above the rectifiers has three openings fitted with resistance element space heaters and pneumatically operated louvres. The intake louvres are also opened and shut pneumatically so that under the control of thermostats, either warmed or unwarmed air can be recirculated or through ventilation used to maintain the rectifiers within the ideal operating temperature range irrespective of load and ambient conditions.

The auxiliary panel for ignition and excitation of each rectifier is mounted in the pressurised space below the tank air seal. This seal consists of a large section hollow rubber ring trapped between two surfaces and allows for deflection of the resilient mountings. Perspex covers allow visual examination of the inside of the rectifier compartment under working conditions.

Any rectifier can be cut out by operation of an excitation control switch from outside the compartment, but the circuits are so arranged that no more than one rectifier can be cut out without rendering the locomotive inoperative.

4.5 *Chokes*

Two D.C. smoothing chokes are connected in series mounted below the underframe. Each choke is a naturally ventilated air cooled unit, consisting of coils wound with flat strip with well spaced concentric turns to allow free air passage, and with an external cylindrical core made up of packets of laminated iron, the whole being enclosed in a fibre-glass case. This method of construction was chosen on account of weight reduction and to keep down the spread of the external magnetic field; splitting the total inductance required into two units suited the particular overall locomotive layout. The inductance of the two reactors in series is 1·0mH at 2,800 amps. D.C.

4.6 *Line Breakers*

D.C. power is switched on and off by means of two high-speed air-operated latched contactors one in each supply line to the rectifier anodes. These have been developed for frequent operation, from a standard sub-station high-speed breaker and have high rupturing capacity coupled with extremely high-speed tripping under reverse current due to rectifier back-fire.

4.7 *Traction Motors*

The 6-pole D.C. series traction motors are identical, apart from mounting details, with those described in Paper 18.

They are fully frame-mounted with 3-point pre-loaded rubber springs, two at the nose of conical form to locate the motors against movement in the bogie frame and one between an extension arm from the motor frame and the bogie headstock.

The drive to the wheels is by means of a hollow quill shaft and flexible link drive developed on the Alsthom system, with 'dancing member' and rubber bushed bearings in the links (fig.9). The quill is carried in the motor frame by large diameter taper roller bearings.

Each pair of traction motors is forced ventilated by means of a centrifugal fan delivering 6,000 c.f.m.

Each fan is mounted in the body above the bogie pivot, an arrangement which allows short ducts of equal length and form to each motor.

4.8 *Master Controllers*

The master controllers consist of cam-operated switch units. These are small moulded units and any single switch can be withdrawn complete by removal of two screws. The power controller and the reverser handle are mechanically interlocked together with the driver's key to prevent mal-operation.

The arrangement of control desk, instruments, warning lights, push-buttons, etc., and method of driving the locomotive have been standardised by the British Railways for all 25 kV A.C. locomotives, irrespective of the actual control apparatus employed.

This is fully described in Paper 3.

With the power controller and reverser thrown to off, the traction motor blowers are stopped and the rectifier short circuit switch closed to either warm up the rectifiers from cold or to maintain temperature when standing for a long period.

4.9 *Auxiliary Motors*

The auxiliary machine driving motors are described in the following table:

No. per Loco.	*Function*	*Supply*		*Rating h.p.*	*Speed r.p.m.*
1	Auxiliary air compressor	Battery	90/ 110V D.C.	1·2	2,000
1	Battery-driven exhauster	Battery	90/ 110V D.C.	3/6·4	600/ 1,200
1	Main air compressor	Rectified A.C.	120V D.C.	9 (hot)	1,200
1	Exhauster	Rectified A.C.	120V D.C.	3/6·4	600/ 1,200
2	Traction motor blowers	S/ph A.C.	139V A.C.	12	2,900
2	Transformer oil coolers	S/ph A.C.	139V A.C.	5	2,900
3	Rectifier fans	S/ph A.C.	139V A.C.	5	2,900
1	Oil circulating pump	S/ph A.C.	139V A.C.	4	1,450

4.10 *Battery Charger*

This unit of the magnestat type with a germanium rectifier was chosen on account of its ability to maintain close control of output over a wide range of input voltage and to maintain its accuracy in service without adjustment.

5. Protection

The system of protection is briefly described as follows:—

Main Transformer – Buchholz relay gives warning of earth, short circuit or low oil level in transformer and finally trips air-blast circuit breaker. Surge protection by Metrosils. High transformer oil temperature also trips air-blast circuit breaker.

Rectifiers – Back-fire protection by high speed circuit breakers in anode feeds. Surge protection by Metrosils.

Traction Motors – Overload relays in each motor circuit trip rectifier anode line circuit breakers.

Earth Fault (other than transformer primary) – System is solidly earthed at rectifier cathodes and a relay operating from a current transformer trips the air blast circuit breaker.

A general alarm light is fitted in each cab and the fault indication panel inside the locomotive body indicates any of the following conditions:

Motor overloads tripped,
Earth fault,
Transformer excessive temperature,
Traction motor blowers stopped,
Rectifier hot or cold,
Rectifier not exciting.

Motor overloads, earth faults, rectifier back-fire, high transformer oil temperature and Buchholz operation leave flag or neon indications which have to be re-set by the maintenance staff.

All H.T. equipment is contained in a compartment with access through one door which is interlocked with the pantograph air valve and roof earthing switch, so that access can only be obtained when the pantographs are down and earthed.

Six axle ends are fitted with earthing brushes insulated from the axle boxes and consisting of a manganese steel brush running on a manganese steel plate on the axle end. Four brushes are connected to the earth side of the transformer primary and two to the locomotive frame. The auxiliary circuits are earthed through the frame.

6. Mechanical Parts

6.1 *Bogies* (*fig.*10)

The bogies are of special interest as the suspension and flexible drive from the frame mounted motors have been developed, using the Alsthom principles, incorporating rubber bearings and pivots.

The bogie frame is fabricated from 'Corten' steel and the design is such that the welding between side frames and cross members is carried out away from the points of maximum stress.

The traction motors with their gears and quill shafts are carried on 3-point pre-loaded rubber mountings in the bogie frames and are coupled to the road wheels by Alsthom type link drives.

The wheel sets are carried in double row spherical roller bearing axle boxes which are connected to the bogie frames by rubber bushed radius arms, giving a cushioned resistance to lateral impacts.

The primary coil springs are mounted on equalising beams underslung from the axle boxes in rubber 'chevron' mountings. Hydraulic dampers are also fitted. The combined primary spring rate of the coil springs and the various rubber elements is 9·4 tons per inch per wheel set.

Separate brake cylinders are provided for each wheel and the employment of reaction support of the inner hangers gives a very simple brake rigging.

The Alsthom type secondary suspension consists of a vertical column between the underframe and bogie fixed bolster with large rubber conical bearings at either end. Tractive effort is transmitted through the rubber, but longitudinal stability of the column is controlled by manganese bearing pads, while side movement is controlled by pre-loaded double acting springs.

A small proportion of the body weight is taken on four coil support springs on each bogie via manganese steel pads. The total combined static secondary spring rate is 16 tons/in. per bogie. Under small transverse accelerations, the body oscillates about the lower pivot only, but under the influence of higher forces sufficient to overcome the pre-loaded side control springs the body can move sideways relative to the bogie ; the combined effect is that the period of natural oscillation is governed to a large extent by the severity of the exciting force. Absence of body roll with this type of suspension is particularly noticeable.

6.2 *Underframe and Body*

The complete body of the locomotive is designed as a weight carrying structure, and consists of a fabricated underframe with side member and centre beams of rolled steel channel section. Between the bolsters, the sideframes, which are riveted to the underframe, are of braced frame construction with deep section cantrails, joined at intervals by transverse members which also carry the pantograph feet. This provides a structure combining lightness with high resistance to buffing shocks and eccentric loading. The transverse members, which also carry the roof traps, are removable, so that the body of the locomotive can be completely opened at the top between the cab bulkheads if required.

The cabs at either end are of the size and layout decided upon by British Railways as the standard for this type of locomotive, and give spacious and comfortable accommodation for the crew.

In order to achieve light weight, the maximum use has been made of fibre-glass construction for such items as cab roofs, doors, bulkheads, air ducts and even the transformer oil conservator tank.

6.3 *Brakes*

The brakes are Westinghouse controlled air vacuum type with direct air brake on the locomotive. Four independent cylinders are provided on each bogie with automatic slack adjusters.

7. Conclusion

In conclusion it can be said that, in order to design and produce an A.C. locomotive of the power and weight called for on 4 axles, it has been necessary to employ techniques and materials not commonly used for traction applications. The use of the well-proved Alsthom principles of rubber suspension units and flexible drive has already indicated during trial running that the riding of these locomotives will be consistently good.

SUMMARY

This paper describes the 25 single-phase rectifier locomotives ordered by B.T.C. from The B.T.H. Co., Ltd, now A.E.I. (Rugby) Ltd. The rectifiers are pumpless steel-tank, mercury-arc type, but 40 similar power equipments ordered for installation in railway-built locomotives have semi-conductor rectifiers with rheostatic braking.

The mechanical parts were manufactured for A.E.I. (Rugby) Ltd by The Birmingham Railway Carriage & Wagon Co., Ltd, and the Alsthom system of rubber suspension and flexible traction motor drive is incorporated.

Some leading particulars of these locomotives are as follows:—

Total weight	80 tons	Wheel arrangements	Bo-Bo
Max. axle load	20 tons	Max. service speed	100 m.p.h.
Max. tractive effort	48,000 lb.	Cont. tractive effort	20,000 lb.
		Cont. h.p.	3,200

The main transformer primary is arranged for series/parallel connection to run on 25 kV or 6·25 kV. The output voltage from the main transformer group can be varied throughout by a tapped winding first bucking and then boosting a fixed voltage, thus giving double the number of steps relative to transformer taps. Tap changing is carried out by quick break contactors operated by a motor-driven camshaft. The output is converted to direct current for the traction motors by the three air-cooled six-anode mercury arc rectifiers, diametrically connected in parallel with load sharing reactors. The motors are connected in parallel.

There is an 826 V winding on the main transformer for train heating. This is reduced by means of an auto-transformer to 139 V for various auxiliary circuits, including single-phase capacitor start and run motors for fans, pumps, etc. The 139 V supply is also rectified by means of semi-conductor rectifiers to supply the battery and compressor and exhauster D.C. motors.

The bogies are fabricated with frame-mounted motors driving through flexible link drives. The roller bearing axle boxes are connected to the frame by rubber-bushed radius arms, and the primary coil springs are mounted on equalising beams, underslung from the axle boxes in chevron rubber mountings.

The secondary suspension consists of a single double rubber cone pivot with spring-controlled lateral movement, and four spring-loaded side bearers.

The complete body of the locomotive is designed as a weight-carrying structure with side frames of continuous braced construction. The maximum use has been made of fibre-glass for panels, ducts and doors.

RÉSUMÉ

Cet exposé décrit les 25 locomotives monophasées 50 Hz à redresseurs, construites à la commande de la British Transport Commission par A.E.I. (Rugby) anciennement B.T.H. Co. Ltd. On emploie des redresseurs à vapeur de mercure sans pompe, en cuve en acier. Il y a cependant quarante équipements électriques semblables avec redresseurs au semi-conducteur et freinage rhéostatique qui sont commandés pour être installés dans les locomotives construites aux ateliers des Chemins de Fer Britanniques.

La firme Birmingham Railway Carriage & Wagon Co. Ltd. a fabriqué les parties mécaniques pour A.E.I. Le système Alsthom de suspension en caoutchouc et l'accouplement élastique du moteur de traction sont utilisés.

Quelques caractéristiques de ces locomotives sont les suivantes:

Poids total	80 tons	Vitesse maximum en service	100 m.p.h.
Charge max. par essieu	20 tons	Effort de traction	
Effort max. de traction	48,000 lb.	continu	20,000 lb.
Disposition d'essieu	Bo-Bo	Puissance du régime continu	3,200 h.p.

L'enroulement primaire du transformateur principal fonctionne à 25 kV ou à 6,25 kV par couplage en série ou en parallèle. On peut varier la tension de sortie du transformateur principal du minimum au maximum au moyen d'un enroulement dont la tension se retranche, puis s'ajoute à une tension fixe doublant ainsi le nombre de prises du transformateur. Le changement de prises s'effectue à l'aide de contacteurs à action rapide, commandés par un arbre à cames actionné par un moteur. Avant d'alimenter les moteurs de traction le courant est converti en courant continu au moyen de 3 redresseurs à six anodes, refroidis par air, chaque unité étant montée en push-pull avec des selfs d'anode pour répartir les charges. Les moteurs sont branchés en parallèle.

Le transformateur principal comprend un enroulement à 826 V pour le chauffage du train. On abaisse aussi cette tension à 139 V au moyen d'un autotransformateur pour alimenter différents circuits auxiliaires comprenant des moteurs monophasés avec condenseurs pour le démarrage at pour la marche, ceux-ci entraînant des ventilateurs, des pompes, etc. La tension de 139 V est aussi redressé au moyen d'un redresseur au semi-conducteur pour alimenter la batterie et les moteurs à courant continu du compresseur et de l'aspirateur.

Les bogies sont construits avec des moteurs suspendus dans le châssis et avec accouplements élastiques Alsthom. Les boîtes d'essieux à roulements sont liés au châssis par des bielles radiales articulées sur du caoutchouc. Les ressorts primaires hélocoídaux sont montés sur des balanciers suspendus aux boîtes d'essieux.

La suspension secondaire comprend un pivot d'acier avec cône double en caoutchouc, ressorts pour le contrôle des mouvements latéraux et quatre supports à ressort aux côtés.

Le caisse complète de la locomotive est construite en forme d'une structure travaillante avec des bâtis latéraux entretoisés par des tringles de renforcement. Le plus grand emploi possible des stratifiés en fibres de verre a été fait pour les panneaux, les conduits d'air, les portières, etc.

ZUSAMMENFASSUNG

Dieser Bericht beschreibt die 25, von der "British Transport Commission" bei der "British Thomson-Houston Co. Ltd." (jetzt "Associated Electrical Industries (Rugby) Ltd.") bestellten, mit 50 Hz Wechselstrom gespeisten Gleichrichter-Lokomotiven. Die Gleichrichter sind vom pumpenlosen Quecksilberdampf-Stahlgefäss Typ. Vierzig ähnliche Ausrüstungen, die zum Einbau in die von der "British Transport Commission" gebauten Lokomotiven bestimmt sind, sind mit Halbleiter-Gleichrichtern sowie Widerstandsbremse versehen.

Die mechanischen Teile für die "A.E.I. (Rugby) Ltd" sind von der "Birmingham Railway Carriage & Wagon Co. Ltd." hergestellt worden, wobei der federnde Fahrmotorenantrieb mit Gummiaufhängung System ALSTHOM in Anwendung gebracht worden ist.

Die Hauptdaten dieser Lokomotiven sind wie folgt:—

Gesamtgewicht	80 tons	Höchstdienst-geschwindigkeit	100 m.p.h.
Max. Achsbelastung	20 tons		
Max. Zugkraft	48,000 lbs.	Dauerzugkraft	20,000 lbs.
Achsanordnung	Bo-Bo	Dauerleistung	3,200 h.p.

Die Primärseite des Haupttransformators wird bei Reihen-bzw. Parallelschaltung an eine Spannung von 25 kV bzw. 6,25 kV angelegt. Die von der Haupttransformatorengruppe gelieferte Spannung lässt sich über den ganzen Bereich mittels einer mit Anzapfungen versehenen Wicklung verändern, welche eine Festspannung erst verkleinert, dann erhöht, sodass, verglichen mit den Transformatoranzapfungen, die Stufenzahl verdoppelt wird. Die Anzapfumschaltungen werden durch Schnellschütze ausgeführt, die mittels einer motorangetriebenen Nockenwelle betätigt werden. Der Gleichstrom für die Fahrmotoren wird durch Umformung der Transformatorausgangsleistung mittels drei luftgekühlter Sechsanoden-Quecksilberdampf-Gleichrichter erhalten; letztere sind über Lastausgleichsdrosseln parallel geschaltet. Die Fahrmotoren sind parallel geschaltet.

Eine 826 V Wicklung am Haupttransformator sorgt für die Wagenheizung. Zur Versorgung verschiedener Hilfskreise, einschliesslich der einphasigen Motoren für den Antrieb der Ventilatoren und Pumpen etc. welche mit den für den Anlauf und Betrieb nötigen Kondensatoren versehen sind, wird diese Spannung mittels eines Spartransformators auf 139 V herabgesetzt. Die 139 V Versorgung dient auch, nach Gleichrichtung durch Halbleiter-Gleichrichter, zur Ladung der Batterie und zur Speisung der 110 V Gleichstrommotoren für den Antrieb des Kompressors und Sauglüfters.

Die Fahrmotoren sind auf die Drehgestellrahmen montiert und treiben die betreffenden Achsen durch elastische Kupplungen vom Typ ALSTHOM an. Die mit Rollenlagern versehenen Lagergehäuse sind durch Radiusarme, welche mit Gummifutter versehen sind, mit dem Rahmen verbunden. Die Hauptspiralfedern sind auf Ausgleichshebeln montiert, welche in den Lagergehäusen in V-förmigen Gummiarmaturen hängend angeordnet sind.

Die Nebenaufhängung besteht aus einem mit zwei Gummikegeln versehenen Drehzapfen mit federnder Seitenbewegung, sowie aus vier federnden Seitenstützen.

Der ganze Oberkasten der Lokomotive ist als gewichttragende Konstruktion mit ununterbrochen versteiften Seiten-Rahmen ausgebildet. Harz gebundene Glasfasern sind soweit wie möglich für die Herstellung von Wandverkleidung, Kanälen und Türen verwendet worden.

RESÚMEN

Este informe describe las 25 locomotoras de tipo monofásico, de 50 Hz, alimentadas por rectificadores, construidas por pedido de la Comisión Británica del Transporte por la empresa B.T.H. Co.

Ltd., ahora A.E.I. (Rugby) Ltd. Los rectificadores son al vapor de mercurio con recipiente de acero pero sin bomba; 40 equipos análogos pedidos para la instalación de unas locomotoras construidas en los talleres de los Ferrocarriles Británicos tienen, en cambio, rectificadores a semi-conductores y el frenaje reostático.

La empresa Birmingham Railway Carriage & Wagon Co. Ltd. ha fabricado pas partes mecánicas por pedido de A.E.I. (Rugby) Ltd., mientras el sistema de suspensión de caucho y la transmisión flexible desde el motor de tracción al eje son de tipo Alsthom.

Unos datos importantes acerca de esas locomotoras son los siguientes:

Peso total	80 tons	Velocidad máxima de marcha	100 m.p.h.
Carga máxima de eje	20 tons		
Fuerza de tracción máxima	48,000 lbs.	Fuerza de tracción continuan	20,000 lbs.
Disposición de ejes	Bo-Bo	C.v. en régimen continuo	3,200 h.p.

El lado primario del transformador principal está acoplado en serie o en paralelo y funciona con suministración de 25 kV o 6,25 kV. El voltaje de la energía tomada del grupo transformador principal puede variarse del mínimo al máximo por medio de tomas en el devanado secundarioj primeramente se reduce y despues se aumenta un voltaje fijo, y por eso el doble del nombro de etapas puede lograrse relativo al nombro de tomas del transformador. El cambio de tomas se efectua por contactores de desenganche momentáneo accionados por un eje de levas movido por un motor. La conversión de energía para alimentar los motores de tracción de corriente continua sigue por medio de una batería de tres rectificadores al vapor de mercurio enfriados por aire, de seis ánodos, diametricamente acoplados en paralelo y con devanados de reactancia para igualar la carga. Los motores asimismo están acoplados en paralelo.

Para la calefacción de los trenes, hay sobre el transformador principal un devanado de 826 voltios. Este voltaje está reducido por medio de un auto-transformador a los 139 voltios empleados por unos circuitos auxiliares, como los motores monofásicos con condensadores para el arranque y la marcha de ventiladores y bombas. La corriente de 139 voltios rectificada por medio de rectificadores semiconductores alimenta el acumulador y los motores de tipo c.c., para compresor y eductor.

Los motores de tracción están colocados sobre el marco del bogie, y la potencia se transmite por medio de la transmisión flexible. Las cajas de cojinetes de suspensión de rodillos tienen brazas radiales con manguitos de caucho para conectarlas al marco del bogie, y los muelles hélicos primarios van colocados sobre balancines de igualación suspendidos de la cajas, en guarniciones de caucho en forma de V.

La suspensión secundaria está compuesta de un pivote de acero con dos conos de caucho, cuyo movimiento lateral está controlado por muelles, y de cuatro soportes laterales de resorte.

El cuerpo completo de la locomotora se proyecta en forma de estructura pudiendo soportar los pesos, con marcos laterales de una construcción reforzada de riostras. La hilacha de vidria está utilizada hasta lo máximo dable para fabricación de paneles, caños de aire y puertas.

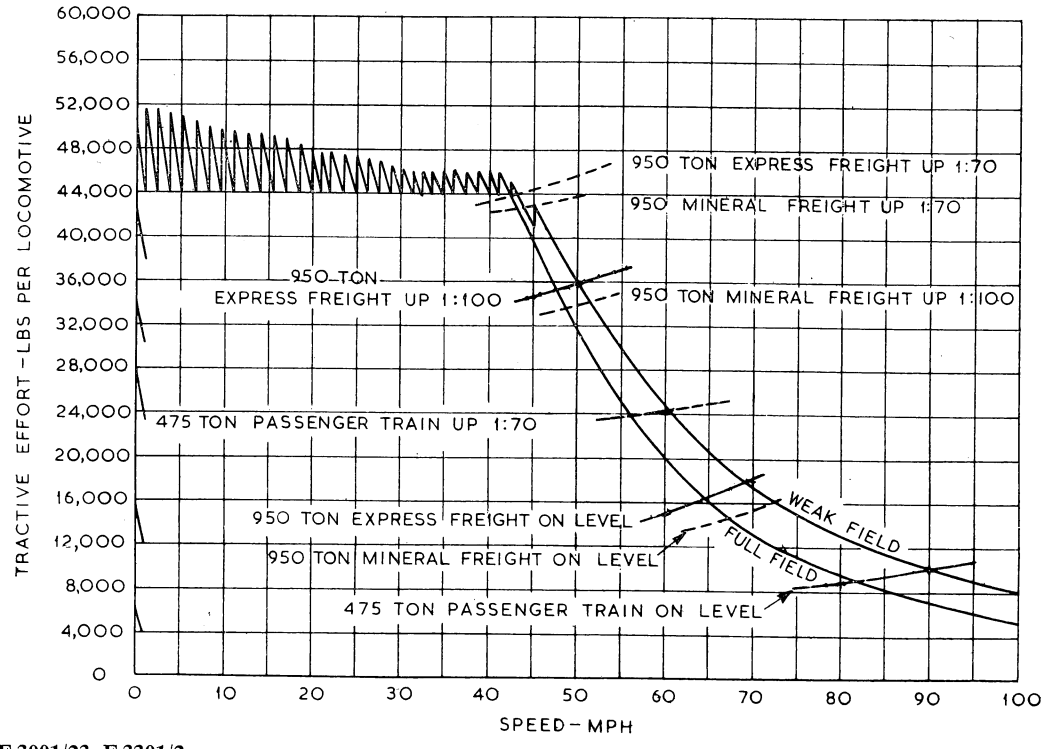


Fig.1 Performance Curve. Nos. E 3001/23, E 3301/2

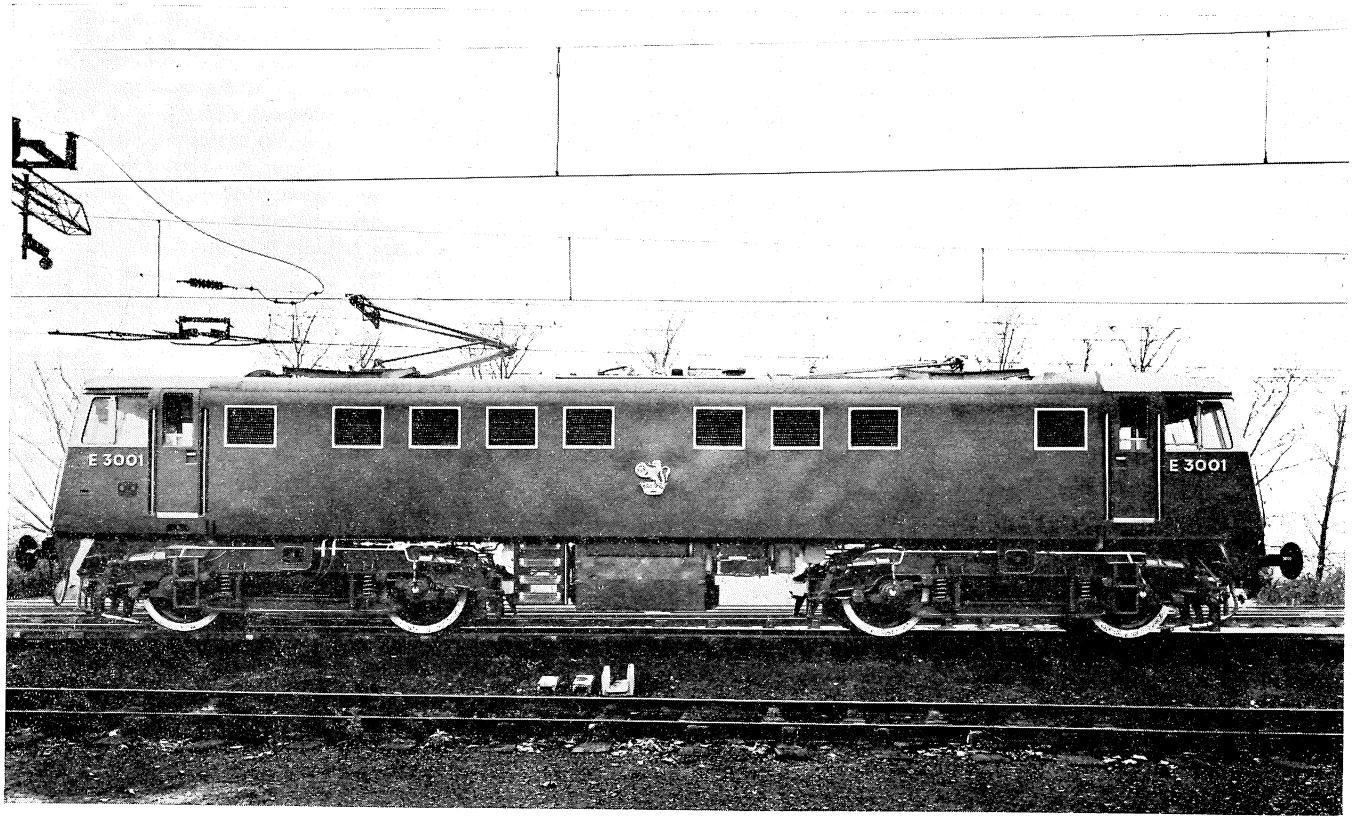
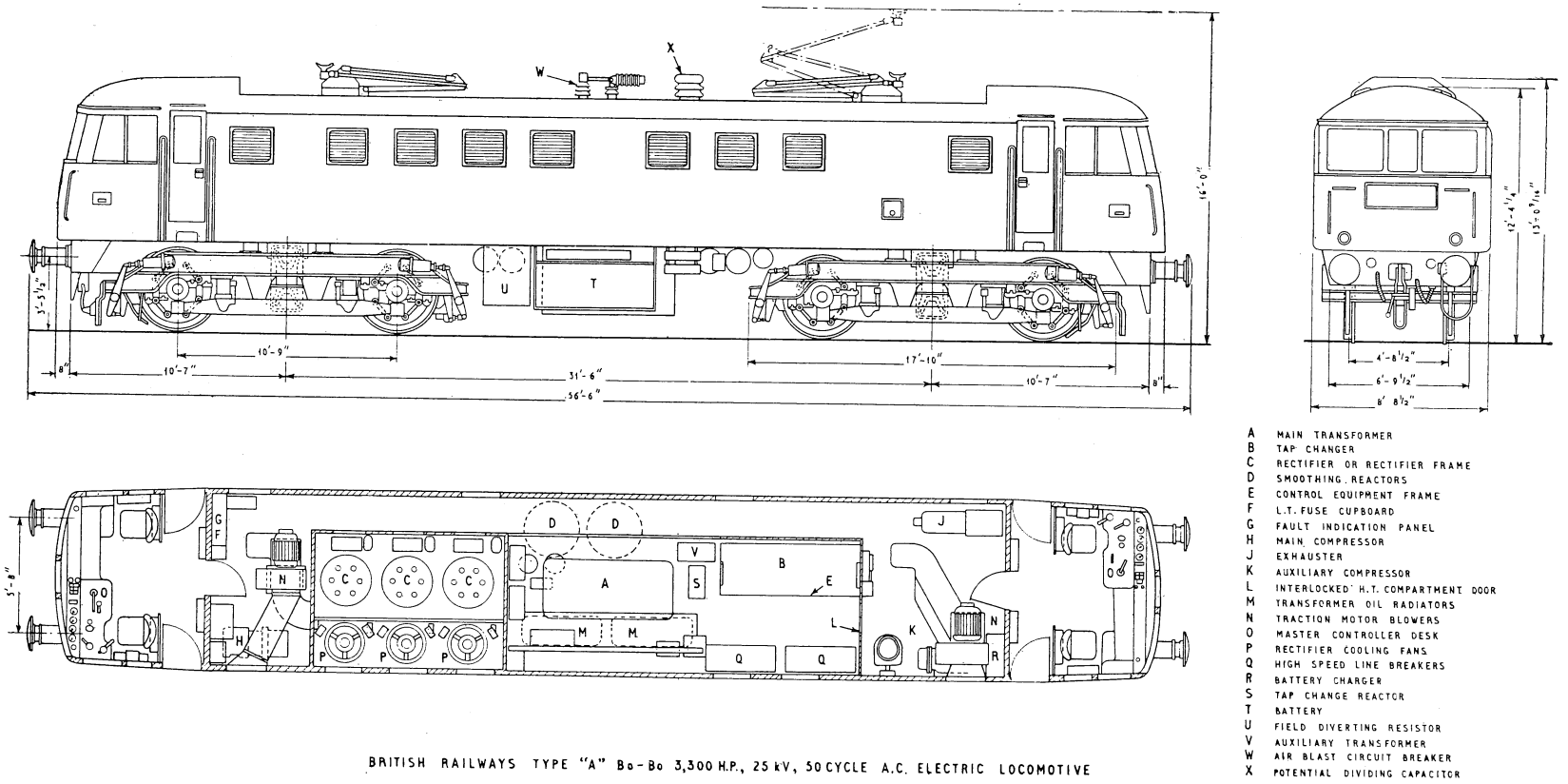


Fig.2 The Locomotive. Nos. E 3001/23, E 3301/2



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

Fig.3 General Arrangement. Nos. E.3001/23, E3301/2.

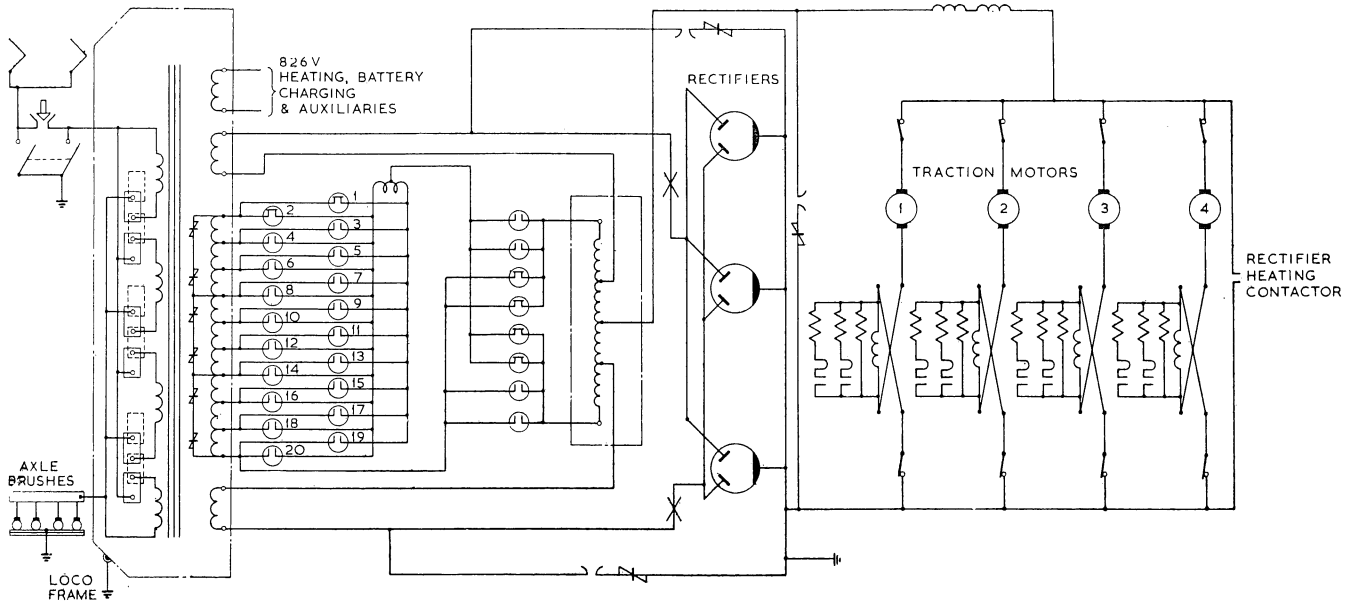


Fig.4 Power Circuit Diagram. Nos. E 3001/23, E 3301/2

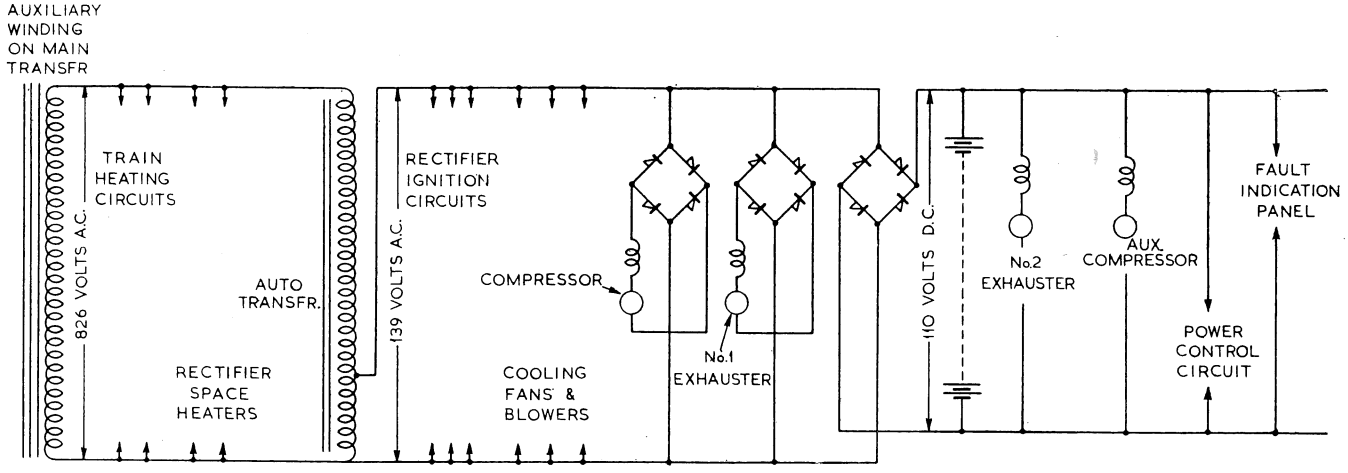


Fig.5 Auxiliary Circuit Diagram. Nos. E 3001/23, E 3301/2

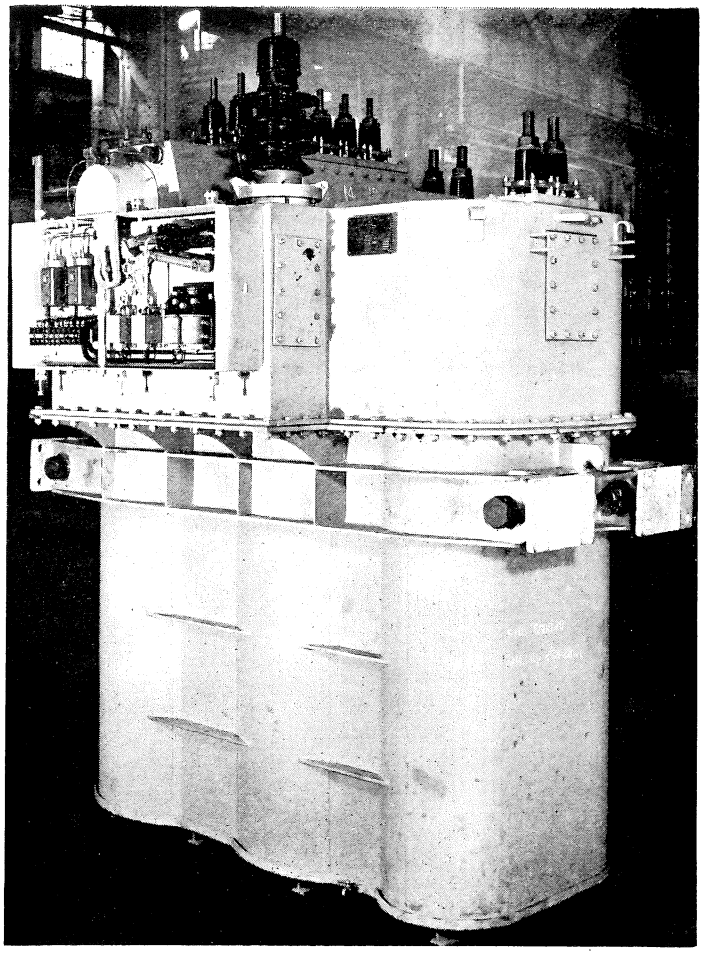


Fig.6 Main Transformer. Nos. E 3001/23, E 3301/2

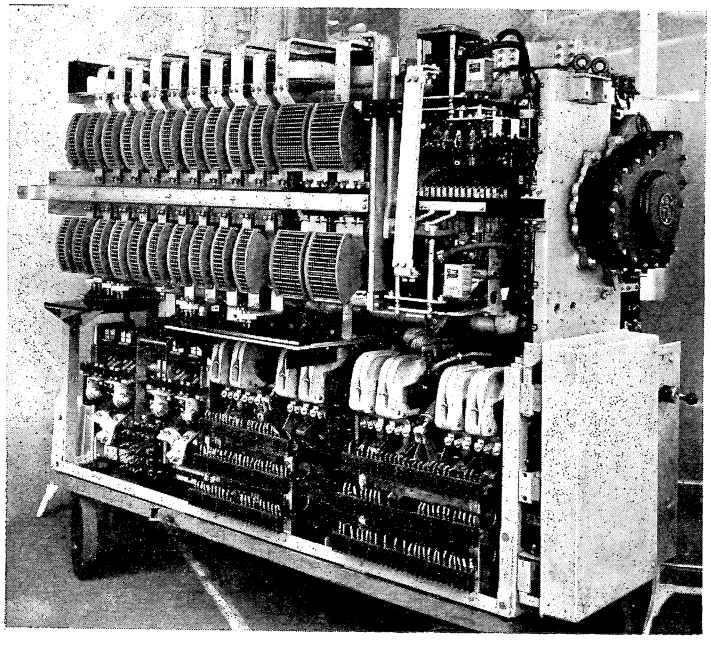


Fig.7 Tapchanger and Control Frame. Nos. E 3001/23, E 3301/2

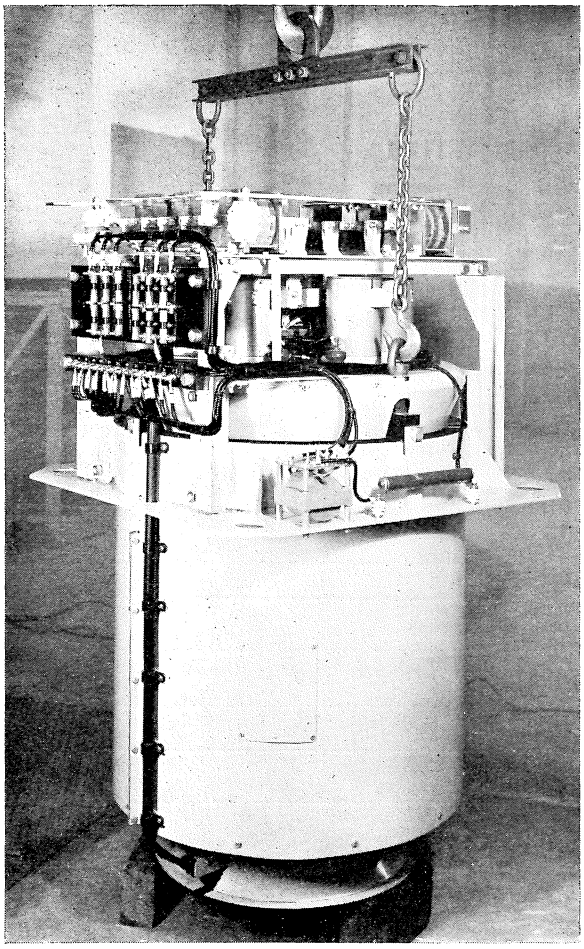


Fig.8 Multi-Anode Rectifier. Nos. E 3001/23, E 3301/2

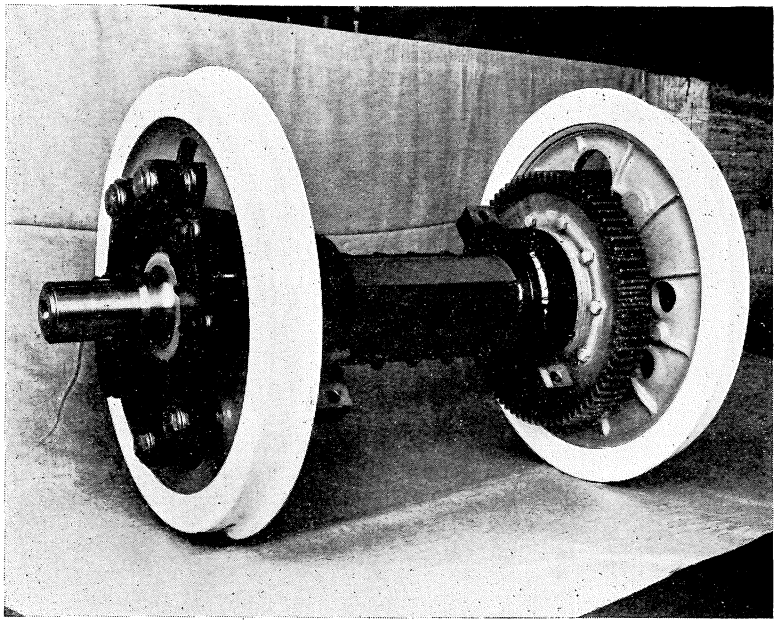


Fig.9 The Alsthom Drive. Nos. E 3001/23, E 3301/2

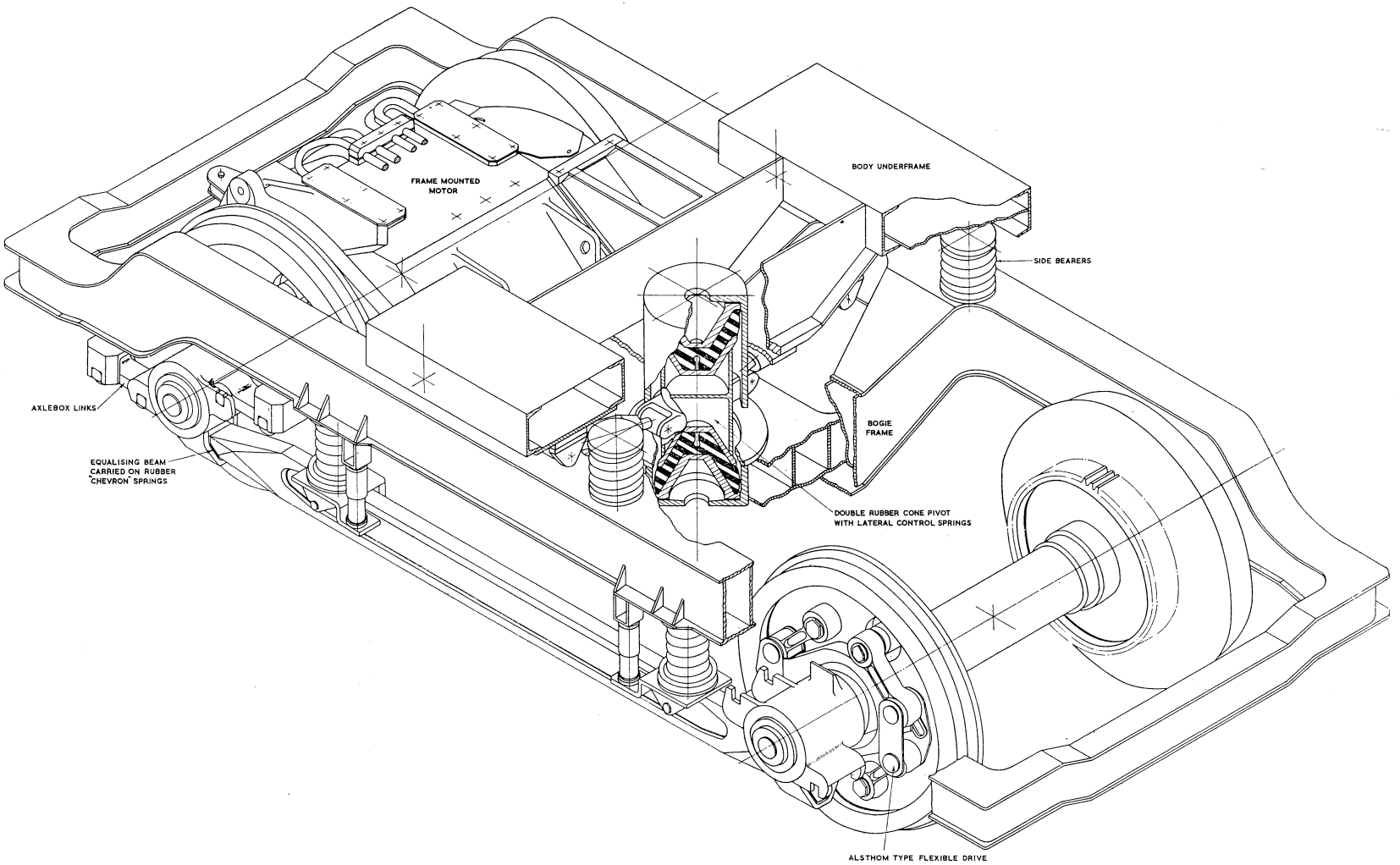


Fig.10 Arrangement of Bogie. Nos. E 3001/23, E 3301/2

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