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Paper 18

# Locomotives: Nos.E3046/55 (A.E.I. Manchester)

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## 1. Introduction

An order for 10 locomotives was placed with Metropolitan-Vickers Electrical Co., Ltd (now A.E.I. (Manchester) Ltd). The complete design of the locomotives has been made by this firm. The electrical equipment has been built at its works in Manchester, Sheffield and Rugby, and the mechanical portions by Beyer, Peacock & Co., Ltd, Manchester.

These locomotives have been designed and built to meet the performance and other requirements of the British Transport Commission Specification AC3 which are briefly described in Paper 3.

## 2. Leading Particulars

Fig.1 is an outside photograph of the locomotive and fig.2 an outline drawing giving also the layout of the major items of equipment.

The principal dimensions and data are:

| | | |
|---|---|---|
| Total weight | | 78·4 tons |
| Maximum axle load | | 19·6 tons |
| Weight of electrical equipment (Including drive) | | 37·7 tons |
| Weight of two bogies (Excluding motors and drive) | | 21·0 tons |
| Weight of underframe and body | | 19·7 tons |
| Length over buffers | | 56′ 0″ |
| Bogie wheelbase | | 10′ 0″ |
| Bogie centres | | 30′ 9″ |
| Wheel diameter | | 48″ |
| Gear ratio | | 29:76 |
| Maximum service speed | | 100 m.p.h. |
| Maximum accelerating tractive effort (average) | | 48,000 lbs. |
| Continuous ratings | *Full Field* | *Weak Field* |
| Tractive effort | 20,000 lbs. | 17,000 lbs. |
| Speed | 62·3 m.p.h. | 73·0 m.p.h. |
| Power | 3,320 h.p. | 3,310 h.p. |

NOTE: The performance figures relate to wheel treads, half-worn tyres, supply voltage of 22·5 kV.

The locomotive performance curves are shown in fig.3.

## 3. Description of Circuits

### 3.1 *Power Circuits*

The locomotive power schematic diagram is shown in fig.4.

The major items of electrical equipment on any rectifier locomotive are the main transformer and associated tap-changing equipment for changing the input voltage to the traction motors, the rectifiers, and the traction motors themselves. Many variants of design of these items and their circuit connections are possible and a proper choice involves many considerations and some compromises. Important considerations in this case have been reliability and weight saving.

On these locomotives variation of the main transformer secondary voltage is achieved by high tension tap changing on an auto-transformer. For locomotives of considerable power output and for which full utilisation of the existing wheel-to-rail adhesion is essential, this system has several advantages, of which the most important are:

(*a*) The currents handled by the tap changer are low, and their rupture can be delegated to a minimum number of circuit breakers.

(*b*) A large number of notches can be provided at low weight and cost, and the voltage increment per notch can be chosen to give a constant tractive effort increase despite the inherently varying slope of the notching (tractive effort/speed) curves.

(*c*) The windings of the step-down transformer remain in circuit over the whole secondary voltage range, so that the impedance remains sensibly constant with obvious benefit to rectifier protection.

(*d*) The losses associated with the transition from one tap to the next are very low, in this particular case approximately 1 kWh for one complete starting sequence up to maximum speed.

(*e*) The tapping resistors are oil immersed and very compact and impose less onerous duty on the contactors than do reactors.

On the other hand, a minor disadvantage of the scheme is that the dual voltage operation, specified for these locomotives, involves a quarter voltage tapping in the auto-transformer with a consequent small increase in transformer kVA and losses and radiator cooling capacity.

Each of the three rectifiers has its anodes grouped to form in effect a two-anode tank, and therefore the biphase system of connections is used. The four traction motors in parallel connection are fed from the cathode connection common to all three rectifiers, and through a common smoothing reactor, from the main transformer secondary mid point.

Should a fault develop necessitating the isolation of traction motors any single motor or bogie pair of motors can be cut out. Similarly, any single rectifier tank can be isolated from the circuit.

The field winding of each traction motor is permanently shunted by non-inductive resistance to by-pass the A.C. current component, and conventional field weakening in two steps gives higher speed at maximum voltage.

### 3.2 *Auxiliary Circuits*

An auxiliary schematic diagram is shown in fig.5.

With the exception of the ignition and excitation circuits for the main rectifiers, which are supplied at 137V A.C., the auxiliary equipment falls into two categories. One of these comprises the majority of the auxiliary machines and all heating circuits on the locomotive which are supplied at 240V single-phase A.C. from a tap on the primary auto-transformer. The other includes the main and auxiliary compressors, the exhauster, all locomotive lighting circuits, and the battery, and is supplied at 110V D.C. from a germanium rectifier bridge which in turn is fed from the 240V A.C. supply through a 240/137V, 16 kVA stepdown transformer.

Battery charging is through a resistor connected in series with the rectifier and this, in conjunction with the charging characteristic of the battery, assists in keeping the D.C. voltage reasonably constant. A battery relay and a contactor are inserted in the D.C. charging circuit between the feeds to the main compressor and the exhauster. In the event of failure of line voltage the compressor cannot operate, but the exhauster for a certain length of time can run off the battery, the abovementioned ballast resistor being by-passed by a single germanium rectifier cell. All control circuits operate at 110V D.C.

## 4. Description of Electrical Apparatus

### 4.1 *Roof Mounted H.T. Equipment*

The Stone-Faiveley pantographs and the air-blast circuit breaker are described in Papers 20 and 3.

The potential measuring device for A.P.C. takes the form of a potential transformer with coils encapsulated in cast resin, the whole being contained in a cast iron box mounted on the roof with the H.T. terminal exposed and the L.T. connection on the underside and inside the locomotive body. The voltage ratio is 22,500/360, with a rating of 180 VA.

A simple surge spill gap of the horn type with adjustable gap is mounted adjacent to one pantograph.

### 4.2 *Main Transformer*

The main transformer stands in a shallow well in the body floor, and the tank top cover plate is level with the locomotive roof. The H.T. terminal is mounted on this cover plate and, being above the roof connects up with the other roof-mounted H.T. equipment without the need for lead-in insulator or cables. A photograph is shown in fig.6.

The complete transformer unit comprises an auto-transformer and a double winding step-down transformer built together on a partly common core and housed in an aluminium tank, on the outside of which is mounted the tap changer with its operating gear and the two air-break switches.

The insulating oil is force circulated and air blast cooled (OFB) and the ratings based on I.E.C. rules, are:

Primary 25/6·25 kV; 3,610 kVA
Secondary 2×1,410V; 5,100 kVA; 12·1 per cent. reactance.
From taps on auto-transformer 896V, 330 kVA for train heating
269V, 110 kVA for auxiliaries.

The normal transformer primary voltage is considered to be 22·5/5·625 kV.

The current rating has been determined by careful consideration of the specified load cycles and the track profile and is 10 per cent. lower than the equivalent total rating of the traction motors.

The auto-transformer has 38 taps to which the tap changer is connected, and three of these are also used for the following other purposes. Taps at 240V and 800V provide a supply for locomotive auxiliaries and train heating respectively, and a tap at 5·625 kV is used as the H.T. input terminal for the lower value supply voltage. The equipment voltage can be raised by 5 per cent. by connecting the 25 kV supply to the 2nd tap from the end. A single pole oil-immersed H.T. changeover switch is mounted inside the transformer tank; it is operated by an air motor flange-mounted to the tank side.

### 4.3 *Tap Changer*

Fig.7 shows the complete tap changer with its cover plate removed.

The tap changer is driven by an electric motor through a Geneva wheel mechanism and comprises two sliding contacts operated by pre-stretched chains. These contacts move along the surface of a vertical row of studs which in turn are connected to the 38 taps on the auto-transformer. The tap changer, together with the carbon type transition resistor, is housed in a rectangular vertical casing which forms an extension to the main transformer tank and is oil-filled. The two current rupturing air break switches which carry out the actual transition from one tap to the next are mounted on insulators on the transformer tank wall; they are mechanically operated by cams on the Geneva drive output shaft whereby synchronism with the movement of the tap changer contacts is ensured.

4.4 *Rectifier Equipment*

A complete rectifier tank assembly is shown in fig.8. A description of the rectifier is contained in Paper 15.

Two intertank reactors are used to ensure equal current distribution between the groups of anodes, whilst tank-mounted anode reactors control the load sharing between individual anodes working in parallel. All of these reactors are air-cooled by the general ventilation of the rectifier compartment.

Each rectifier tank is carried on an aluminium framework, directly above its own axial flow cooling fan mounted in a recess in the floor. When the temperature in the rectifier compartment exceeds a certain limit, another fan circulates cooling air from outside through the compartment and expels it through shuttered apertures in the locomotive roof. Before the rectifiers can be put on load, under conditions of low ambient temperatures, anode and space heaters, the latter taking the form of rings surrounding each of the rectifier fans, bring the essential tank components to a safe temperature. This is followed by a short period of general preheating during which the rectifiers are supplied at a suitable low transformer voltage with the D.C. output terminals short-circuited.

4.5 *Smoothing Reactor*

The positive D.C. busbar which connects the three rectifier cathodes, is at earth potential. The negative busbar is connected to the transformer secondary mid-point through a single iron-cored smoothing reactor designed to limit the A.C. ripple to 37 per cent. at the total continuous current of the four traction motors. In the interests of weight economy, the reactor core is designed to be partly saturated under these conditions. A virtue of this necessity is that in the event of motors being cut out, the effective smoothing effect is not unduly reduced. The choke has Class H insulation and is forced-air cooled by a separate centrifugal fan.

4.6 *Driver's Controls*

The design of these controls and their layout are explained in Paper 3.

4.7 *Traction Motors*

The traction motors are of 6-pole design with interpoles and lap-wound armatures; Class H insulating materials are used and the continuous rating to B.T.C. Specification A.C.3, with the normal forced-air cooling rate of 3,000 c.f.m., is 975V, 700 amps, 847 s.h.p.

The motor is of the same general type as that used for D.C. traction, but in order to keep the interpole flux in phase with the armature current under conditions of heavy superimposed A.C. ripple, a shallow laminated ring is clamped to the inside of the main yoke casting so that it directly connects the poles.

As indicated in the bogie drawing fig.10 the motor is carried in the bogie frame by a three point suspension through resilient rubber bushings. This involves a flexible coupling to the axle and a drive of the Alsthom type is used.

4.8 *Auxiliary Equipment*

Tabulated below are the essential particulars of the auxiliary machines.

Compressors and exhausters are Worthington-Simpson and Bristol air-cooled reciprocating machines. The transformer oil pump (of Pulsometer make) and its motor are of glandless unit construction with submerged rotor. Individual rectifier fans are axial flow; all other fans are centrifugal.

Series wound D.C. motors are used to drive the compressors and exhauster in order to give the high starting torque which they require. Capacitor start and run single phase induction motors are used for pump and fans.

Table of Auxiliaries.

| *No. per Loco* | *Function* | *Output* | *Supply* | *Rating h.p.* | *Speed r.p.m.* |
|---|---|---|---|---|---|
| 1 | Oil pump | 200 g.p.m. 9 p.s.i. | 240V A.C. | 2½ | 1,430 |
| 3 | Rectifier air circulating fan | 4,000 c.f.m. 1″ s.w.g. | 240V A.C. | 1¼ | 1,430 |
| 1 | Rectifier air intake fan | 10,000 c.f.m. 1″ s.w.g. | 240V A.C. | 3 | 1,430 |
| 1 | Smoothing reactor fan | 2,000 c.f.m. 1½″ s.w.g. | 240V A.C. | 1¼ | 1,430 |
| 1 | Radiator fan | 16,700 c.f.m. 1·6″ s.w.g. | 240V A.C. | 9 | 1,430 |
| 4 | Traction motor blowers | 3,000 c.f.m. 7½″ s.w.g. | 240V A.C. | 5 | 2,900 |
| 1 | Main compressor | F.a.d. 29 c.f.m. 100 p.s.i. | 110V D.C. | 8½ | 900 |
| 1 | Exhauster | Swept volume 104 c.f.m. | 110V D.C. | 5 | 660 |
| | | Swept volume 141 c.f.m. | 110V D.C. | 7 | 890 |
| 1 | Aux. Compressor | F.a.d. 3 c.f.m. | 110V D.C. | 1 | 1,450 |

## 5. Protection

Access to both locomotive compartments containing exposed live equipment and connections is through doors which are so interlocked that they can be opened only after the air supply to the pantographs has been cut off and all high tension circuits connected to earth.

The primary winding of the main transformer is protected, in the event of earth faults, by the main circuit breaker and a differential relay supplied from current transformers at the H.T. and earth ends of the winding.

Should the primary current earth return path be accidentally completely interrupted, a static earthing device connected to the 800V train heating tap comes into operation and connects this tap solidly to earth through the locomotive frame and wheels.

One 3-element overload relay is connected in each phase on the transformer secondary, one element being in series with each winding on the intertank reactors. These relays, on tripping, open the air-blast circuit breaker. Indication of rectifier backfires is given by polarised relays connected in series with each rectifier cathode. There is also an overload relay in each traction motor circuit, controlling the motor contactors which isolate the motor.

Earth fault protection for the L.T. power circuits is afforded by a relay which trips the circuit breaker if the rectifier cathode potential reaches approximately 36V above earth.

Metrosil surge diverters in series with spark gaps are connected across the transformer secondary winding and the D.C. load circuit and Metrosil diverters only across individual windings on the intertank reactors.

Protection of all auxiliary and control circuits is by fuses. Proving relays check the running of the oil pump and essential cooling fans, and a float switch will open the circuit breaker if the transformer oil level falls below a minimum value.

## 6. Mechanical Parts

As fig.1 shows, the mechanical part of this Bo-Bo locomotive is of the conventional double cab, double bogie type with drawgear on the body underframe and neither articulating nor guiding connections between the bogies. The suspension of body on bogies is of 'Metrovick' swing link type.

### 6.1 *Bogie*

Fig.9 is a photograph of a motored bogie and fig.10 shows the bogie arrangement.

Each bogie is a one-piece steel casting by English Steel Corporation, of which the substantial transom carries the downward projecting pivot pin through which tractive and braking forces are transmitted to the body.

The bogie frame is supported by two forged steel equaliser beams through the primary suspension comprising four nests of helical springs, each adjacent to a hydraulic damper. The ends of the equaliser beams rest on rubber pads on top of the axle boxes.

Secondary suspension comprises two groups of helical springs, in the top surface of each end of the transom; the two groups support a transverse spring cap. This is a steel casting which has its counterpart in the bolster of a conventional suspension system. Two rubber bushed radius links act as 'bolster anchors' in restraining longitudinal movement of the spring cap in relation to the bogie frame, and its transverse movement is restricted by cushion pads.

The static deflections of primary and secondary suspensions are 2·75 in. and 2·25 in. respectively.

*Wheels and Axles*

Each wheel axle set is provided with Timken taper roller bearing axle boxes. The box at one end is restrained laterally, i.e. in the direction of the axle, by two rubber bushed links attached to the bogie frame. The box at the other end of the axle has no such restraint. In this way the riding qualities of the vehicle, which depend so much on close lateral location of the axle in the bogie, are not dependent on frequent rectification of transverse wear of conventional axle box slides.

*Flexible Drive*

The components of the Alsthom flexible drive, shown in fig.11, are of the usual type. The radial quill clearance on its axle is 1·25 in. and stops limit the axle box vertical movements to a smaller figure.

### 6.2 *Body Suspension*

Each end of the spring cap member is recessed to house a hemispherical rubber resilient joint for a body suspension link.

At its lower end this link is equipped with a similar resilient joint housed in the lower end of one of the four body support struts. These are fabricated steel downward extensions of the body underframe, passing outside the bogie frames. Each pair has its lower ends tied together by a detachable transverse beam passing under the bogie frame.

This beam carries the bush in which the bogie pivot pin slides and by which the traction and braking forces are transmitted from bogie to body. To avoid restraint to the body bogie lateral movements the bush is mounted in a parallel motion Z linkage with rubber resilient joints. The free lateral movement of 1·75 in. each way is snubbed by rubber buffers of progressive stiffness.

The traction force transmission is at axle level and this in conjunction with a freely tipping bogie results in very limited transfer of weight between axles due to tractive effort.

The suspension system described gives all the benefits of the swing bolster principle without the wear and the need for maintenance associated with metal pivoting and sliding members. The rubber joints isolate the body from the noise and high frequency vibration which can be transmitted through springs. They also provide some damping against cyclic oscillations but this is augmented by hydraulic dampers mounted horizontally between the bogie corners and the body to control the lateral and pivoting movements.

*Underframe and Body*

The body underframe is a welded steel structure of which the main strength lies in two vertical side plates 0·625 in. thick and 24 in. deep which run the full length and to which are secured the body support struts. Fabricated cross bracing stabilises the side plates and supports the floor.

In the interests of weight economy the whole superstructure of carlines, cantrails and body panels and equipment supports is constructed of aluminium alloy. Much of the roof is of reinforced resin bonded fibreglass, which being translucent provides daylight illumination inside the body.

*Ventilation*

The ventilation arrangements are necessarily somewhat involved. Lying horizontally in the roof alongside the transformer is the cooling radiator (of Serck manufacture), with a vertical axis fan below it. The air expelled upwards by this fan is drawn in through a side wall louvre. A branch air circuit fed through the same louvre by another fan draws air through the auxiliary rectifier and expels it through the smoothing choke.

The part of the compartment which houses the rectifiers has an independent ventilation system comprising the thermostat controlled main circulation fan working in conjunction with the individual rectifier fans and discharging through a shutter controlled louvre on the roof.

The traction motor fans draw their air supply through independent side wall louvres and ducting.

### 6.3 *Brakes*

The Metcalfe-Oerlikon equipment provides the system of braking described in Paper 3. For weight economy reasons brake piping, air reservoirs and certain fittings are of aluminium alloy.

## 7. Conclusion

Throughout the design of these locomotives, an ever present consideration has been weight saving and it has led to the use of materials and constructions less economical than the optimum. System tests and operating experience with these and other designs of locomotive may well point the way to less expensive methods of weight reduction, for instance smaller smoothing reactors and semi-conductor rectifiers may ease the problem.

Information regarding the dates of setting these locomotives to work and the results of their system tests are to be found in Paper 2.


## SUMMARY

This paper describes A.C. 50 cycle locomotives built for B.T.C. by A.E.I. (Manchester) Ltd (formerly Metropolitan-Vickers Electrical Co., Ltd).

They are of the Bo-Bo wheel arrangement and have two driving cabs; they are geared for 100 m.p.h. maximum service speed, have a continuous rating of 3,320 h.p., can operate on a 25 kV or 6·25 kV supply and weigh 78·4 tons.

Power conversion from 50 cycle single phase supply to an undulating unidirectional current for the almost conventional D.C. traction motors is by means of a mercury arc rectifier comprising three multi-anode air-cooled sealed steel tanks working in biphase to feed in parallel to the four parallel connected motors.

Regulation of power is by a 38 step tap changer on the high tension side of the main transformer unit, which comprises an auto-transformer with multiple tappings and a fixed ratio step down transformer, both in one tank. The transformer is oil immersed as is also the tap changer mechanism other than the two air break contactors which perform all make and break duties.

An air blast circuit breaker on the roof protects from the consequences of overloads on the transformer secondary and from earth faults on transformer primary and low tension power circuits.

The auxiliary machines such as fans and pumps with low starting torque requirements are driven by single phase induction motors with capacitors for start and run, but the reciprocating compressor and exhauster have D.C. driving motors fed by a germanium rectifier.

The traction motors are bogie mounted and drive their respective axles through Alsthom flexible couplings.

The body is carried on the two cast steel bogies by a support system which is a development of the Metrovick swing link suspension, in which all pivoting members have joints of the rubber resilient type, ensuring good riding and eliminating wear and the need for lubrication. Traction forces are transmitted between bogies and body at axle level to minimise weight transfer.

Most of the body structure is of aluminium alloy and resin bonded fibreglass has been freely used.

The weights of the electrical and mechanical parts of the locomotive are 37·7 and 40·7 tons respectively.



## RÉSUMÉ

Cet exposé décrit les locomotives à courant alternatif 50 Hz construites à la commande de la British Transport Commission par A.E.I. (Manchester) (autrefois Metropolitan-Vickers Electrical Co., Ltd).

Celles-ci ont la disposition d'essieux Bo-Bo et deux cabines de conduite. Le rapport d'engrenages est prévu pour la vitesse maximum de 100 m.p.h. Elles ont au régime continu une puissance de 3320 h.p. et fonctionnent à 25 kV ou à 6,25 kV. Une telle locomotive pèse 78,4 tons.

A l'aide des redresseurs à vapeur de mercure on transforme le courant monophasé à 50 Hz de la caténaire en courant ondulé pour alimenter les moteurs de traction à courant continu presque classiques. Les trois cuves en acier scellées sont refroidies par air. Ces cuves polyanodiques fonctionnent en ' push-pull ' pour alimenter les quatre moteurs couplés en parallèle.

Le réglage de la puissance s'effectue au moyen d'un graduateur à 38 échelons sur l'enroulement haute tension du transformateur principal, comportant un autotransformateur à prises multiples conjointement avec un transformateur abaisseur au rapport de transformation constant, tous deux se trouvant dans la même cuve. Le transformateur se trouve dans l'huile, de même que le graduateur, sauf les deux contacteurs dans l'air qui effectuent toutes les opérations de fermeture et de coupure.

On se sert d'un disjoncteur pneumatique sur la toiture pour assurer la protection contre les surcharges côté secondaire du transformateur et contre des défauts de terre côté primaire, ainsi que dans les circuits à basse tension.

Des moteurs d'induction monophasés avec condensateurs pour le démarrage et la marche normale actionnent les machines auxiliaires avec faible couple de démarrage, telles que des ventilateurs et des pompes, mais le compresseur à mouvement alternatif et l'aspirateur ont des moteurs à courant continu, alimentés au moyen d'un redresseur au germanium.

Les moteurs de traction sont montés dans les bogies; chaque moteur entraîne son essieu par l'accouplement élastique Alsthom.

La caisse de voiture est portée par les deux bogies en acier coulé, par l'intermédiaire d'un système qui est un développement de la

suspension à bielles Metrovick; tous les éléments pivotants de cette suspension ont des articulations amorties par des cales en caoutchouc. De ce fait une suspension douce est garantie, l'usure est supprimée ainsi que le besoin de lubrication.

Les efforts de traction sont transmis entre les bogies et la caisse à l'hauteur de l'essieu, dans le but de réduire le cabrage au minimum.

La plus grande partie de la caisse est construite en alliage à base d'aluminium et on a utilisé abondamment des quantités assez grandes de stratifiés en laine de verre.

Le poids des parties éléctrique et mécanique est respectivement de 37,7 et 40,7 tons.


**ZUSAMMENFASSUNG**

Der Bericht beschreibt die 50 Hz Wechselstrom-Lokomotiven für die " British Transport Commission ", hergestellt von " Associated Electrical Industries (Manchester) Ltd ", (früher " Metropolitan-Vickers Electrical Co. Ltd ").

Die Lokomotiven sind mit Achsen in der Anordnung Bo-Bo und mit zwei Führerkabinen ausgerüstet. Die Getriebe sind für eine Höchstgeschwindigkeit von 100 m.p.h. gebaut. Die Lokomotiven haben eine Dauerleistung von 3320 h.p., wiegen 78.4 tons und sind für Fahrdrahtspannungen 6.25 kV und 25 kV gebaut.

Die fast konventionellen Gleichstrom-Fahrmotoren werden mit gleichgerichtetem Wellenstrom gespeist, den man durch Umwandlung der einphasigen 50-Hz-Versorgung mittels eines Quecksilberdampf-Gleichrichters bestehend aus drei luftgekühlten, luftabgeschlossenen, zweiphasig-arbeitenden Mehranoden-Stahlgefässen erhält; die vier parallel geschalteten Motoren werden parallel gespeist.

Die Energie wird durch einen auf der Hochspannungsseite des Haupttransformators angebauten 38-stufigen Lastregelschalter geregelt. Der Haupttransformator besteht aus einem mit mehreren Anzapfungen versehenen Spartransformator sowie einem heruntertransformierenden, mit fester Übersetzung versehenen Transformator, die beide in ein und demselben Kessel sind. Der Transformator sowie die Anzapfumschaltermechanismen, mit Ausnahme der beiden alle Zu- und Abschaltungen leistenden Luftschütze, stehen unter Öl.

Ein auf dem Dach montierter Druckluftschalter schützt gegen Ueberlastung der Transformatorsekundärseite, sowie gegen Erdschlüsse der Transformatorprimärseite und in den Niederspannungsstromkreisen.

Die Hilfsmaschinen, wie z.B. die Ventilatoren und Pumpen, die ein nur niedriges Anzugsdrehmoment beanspruchen, sind mit einphasigen Induktionsmotoren und Kondensatoren für Anlauf und Betrieb ausgerüstet, während der Kolbenkompressor sowie der Sauglüfter von Germaniumgleichrichter gespeisten Gleichstrommotoren angetrieben werden.

Die Fahrmotoren sind auf die Drehgestelle montiert. Die betreffenden Achsen werden über ein elastisches Kupplungs-System Alsthom angetrieben.

Der Oberkasten wird von zwei aus Gusstahl bestehenden Drehgestellen getragen. Die Abstützung wurde aus dem "Metrovick" Pendelaufhängungssystem heraus entwickelt; alle sich drehenden Teile sind mit gummielastischen Gelenken versehen welche gute Tragverhältnisse, Beseitigung von Verschleiss und der sonst nötigen Schmierung gewährleisten. Die Zugkräfte zwischen Drehgestellen und Oberkasten werden auf Achshöhe übertragen um die Gewichtsübertragung möglichst zu vermindern.

Der Oberkasten besteht hauptsächlich aus legiertem Aluminium, harzgebundene Glasfasern wurden ebenfalls in Anwendung gebracht.

Die Gewichte der elektrischen bzw. mechanischen Teile der Lokomotive betragen 37.7 bzw. 40.7 tons.



**RESÚMEN**

Este folleto describe locomotoras para corriente alterna de 50 ciclos, construidas para la Comisión Británica del Transporte por A.E.I. (Manchester) Ltd (antiguamente Metropolitan-Vickers Electrical Co. Ltd).

Las locomotoras tienen dos cabinas de control y la disposición de las ruedas sigue el sistema Bo-Bo; la relación de engranaje está diseñada para una velocidad máxima en servicio de 100 m.p.h. y tienen una potencia en régimen contínuo de 3320 h.p.; operan en lineas de 25 kV o 6.25 kV y pesan 78.4 tons.

La conversión de energía del sistema monofásico de 50 ciclos a la corriente unidireccional ondulante, que alimenta los motores convencionales de tracción de corriente contínua, se efectua por medio de un rectificador de vapor de mercurio, consistente de tres tanques herméticos de acero, enfriados por aire, con ánodos multiples que trabajan bifásicamente para alimentar en paralelo los cuatro motores conectados en paralelo.

La regulación se lleva a cabo mediante el uso de un cambiador de tómas con 38 tómas, conectado en el lado de alta tensión de la unidad principal de transformación, la cual consiste de un auto-transformador con varias tómas y un transformador de baja tensión, de relación fija, ambos en un solo tanque. El transformador está sumergido en aceite así como el mecanismo del cambiador, excepto los dos contactores al aire que afectuan los trabajos de interrupción y cierre del circuito cambiador.

Un disyuntor neumático montado sobre el techo protege el equipo contra las sobrecargas en el secundário del transformador, así como contra las faltas a tierra en el primário y en los circuitos de fuerza a baja tensión.

Los aparatos auxiliares con bajo par de arranque, tales como ventiladores y bombas, son accionados por motores monofásicos de inducción con condensador para el arranque y la marcha. En cambio, el compresor de acción recíproca y el exhaustor tienen motores de corriente contínua, alimentados por rectificadores de germanio.

Los motores de tracción están montados en los bogies y arrastran sus respectivos ejes mediante el sistema Alsthom de acoplamiento flexible.

La corroceria esta montada sobre los dos bogies de acero fundido por medio de un sistema de soporte, el cual es desarollo de la suspensión de Eslabón Pivotante Metrovick. En esta suspensión, todas las partes pivotantes tienen uniones de caucho resiliente, garantizando una marcha suave y eliminando el desgaste y la necesidad de lubricación.

Las fuerzas de tracción se transmiten entre los bogies y la carrocería, al nivel de los ejes, reduciendo la transferencia de peso.

La mayor parte de la estructura de la carrocería es de aleación de aluminio; fibra de vidrio resinosa se usa extensamente.

Los pesos de las partes eléctricas y mecánicas de la locomotora son de 37.7 y 40.7 tons respectivamente.

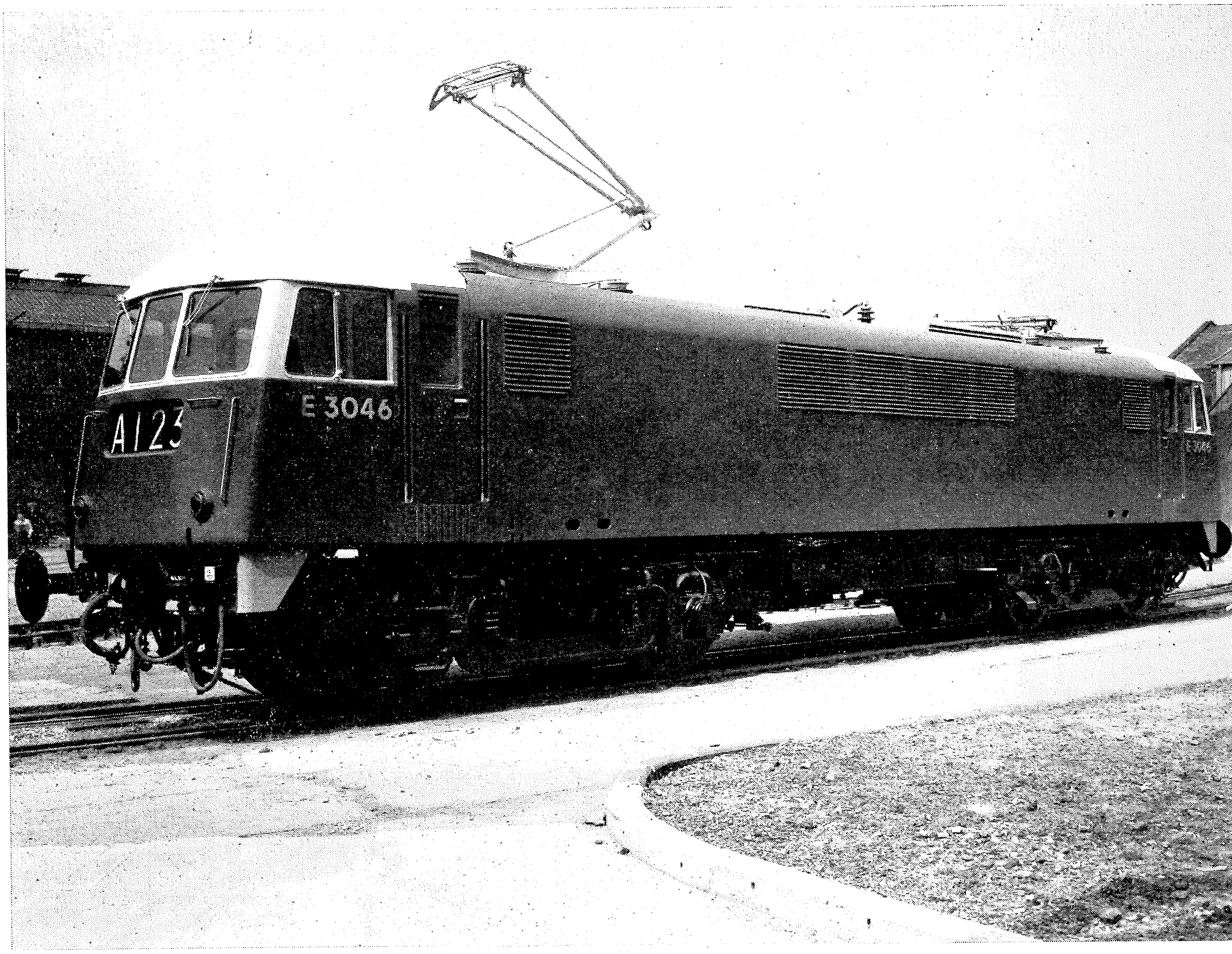
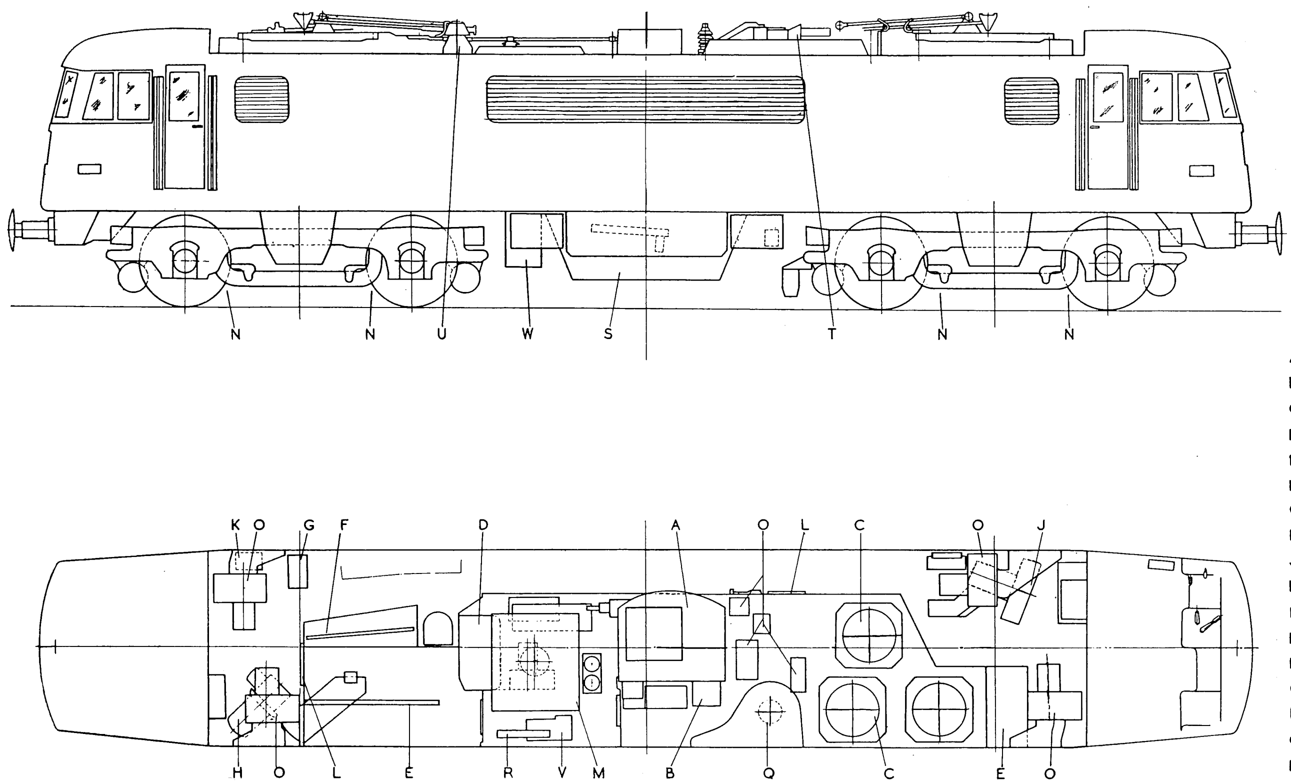
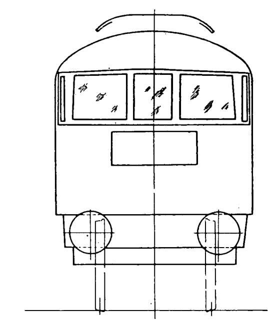



**Fig.1 Complete locomotive. Nos.E.3046/55**





A MAIN TRANSFORMER
B TAP CHANGER
C RECTIFIER
D SMOOTHING REACTOR
E CONTROL EQUIPMENT FRAME
F L.T. FUSE CUPBOARD
G FAULT INDICATION PANEL
H MAIN COMPRESSOR
J EXHAUSTER
K AUXILIARY COMPRESSOR
L INTERLOCKED H.T. COMPARTMENT DOOR
M TRANSFORMER OIL RADIATOR
N TRACTION MOTORS
O TRACTION MOTOR BLOWERS
P IGNITION & EXCITATION EQUIPMENT
Q RECTIFIER INTAKE FAN
R AUXILIARY RECTIFIER
S BATTERY
T AIR BLAST CIRCUIT BREAKER
U POTENTIAL TRANSFORMER
V OIL PUMP
W AUXILIARY TRANSFORMER

**Fig.2 General arrangement. Nos.E.3046/55**

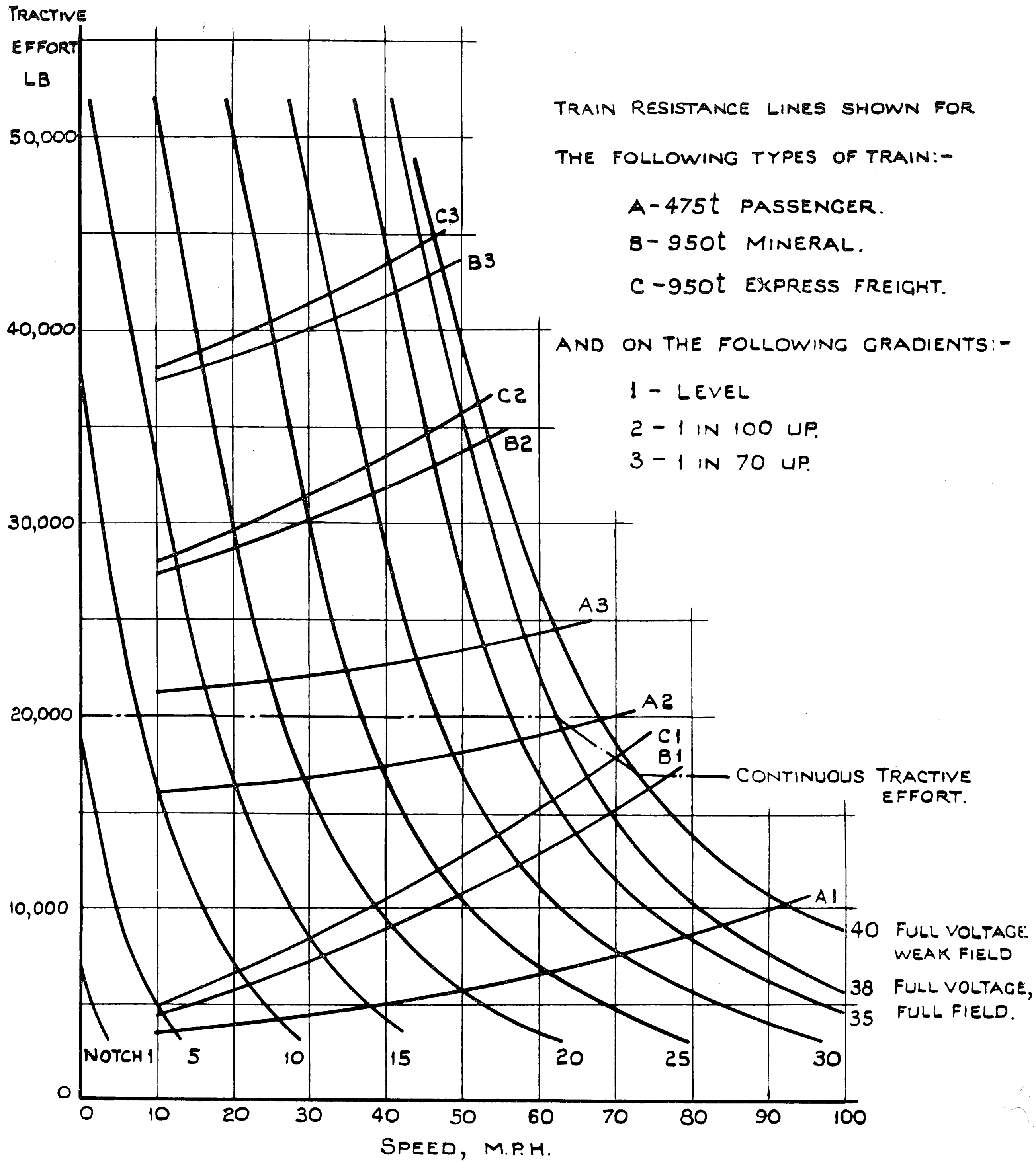



**Fig.3 Locomotive performance curve supply voltage 22·5 kV half worn wheels. Nos.E.3046/55**

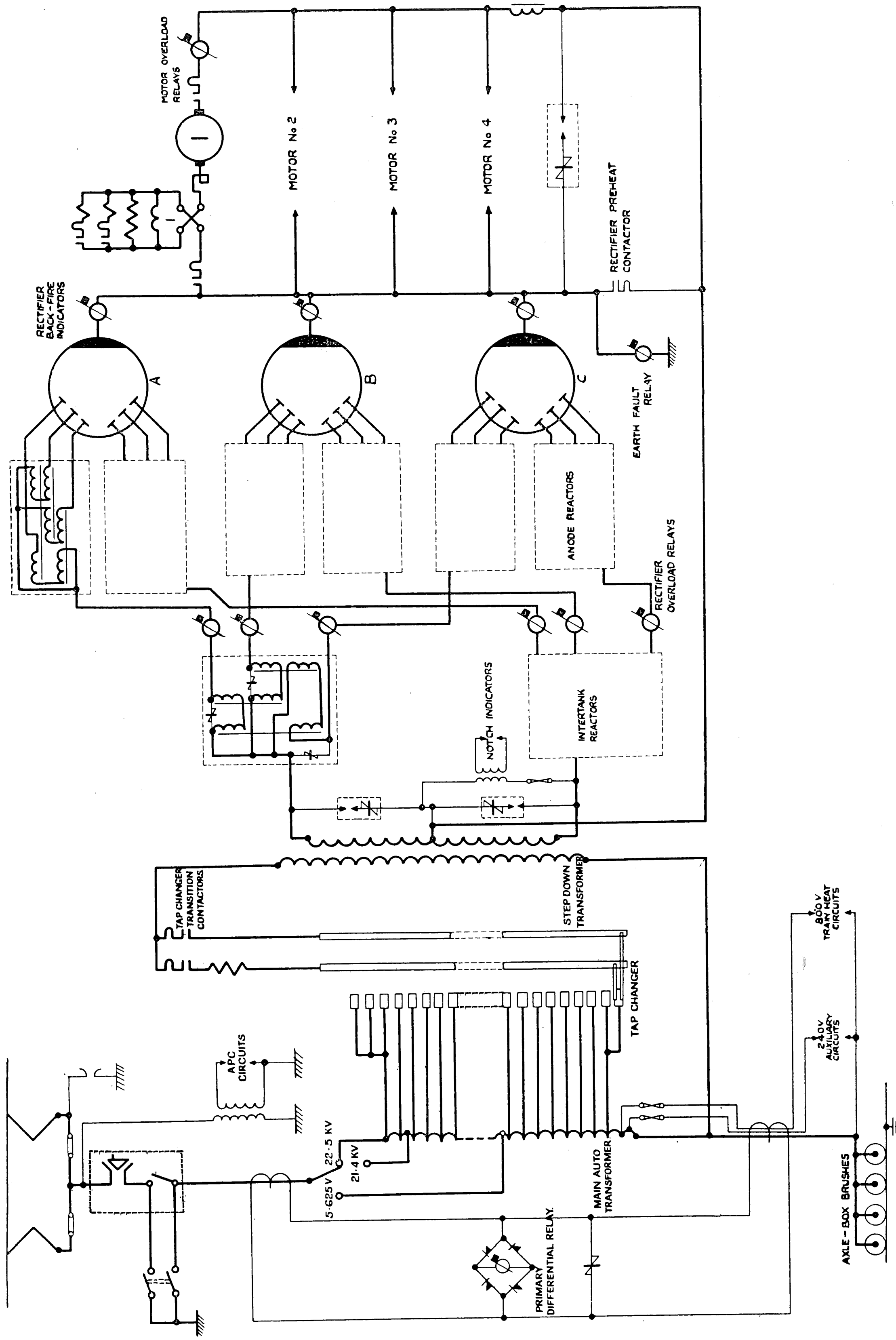



**Fig.4 Power schematic diagram. Nos. E.3046/55**

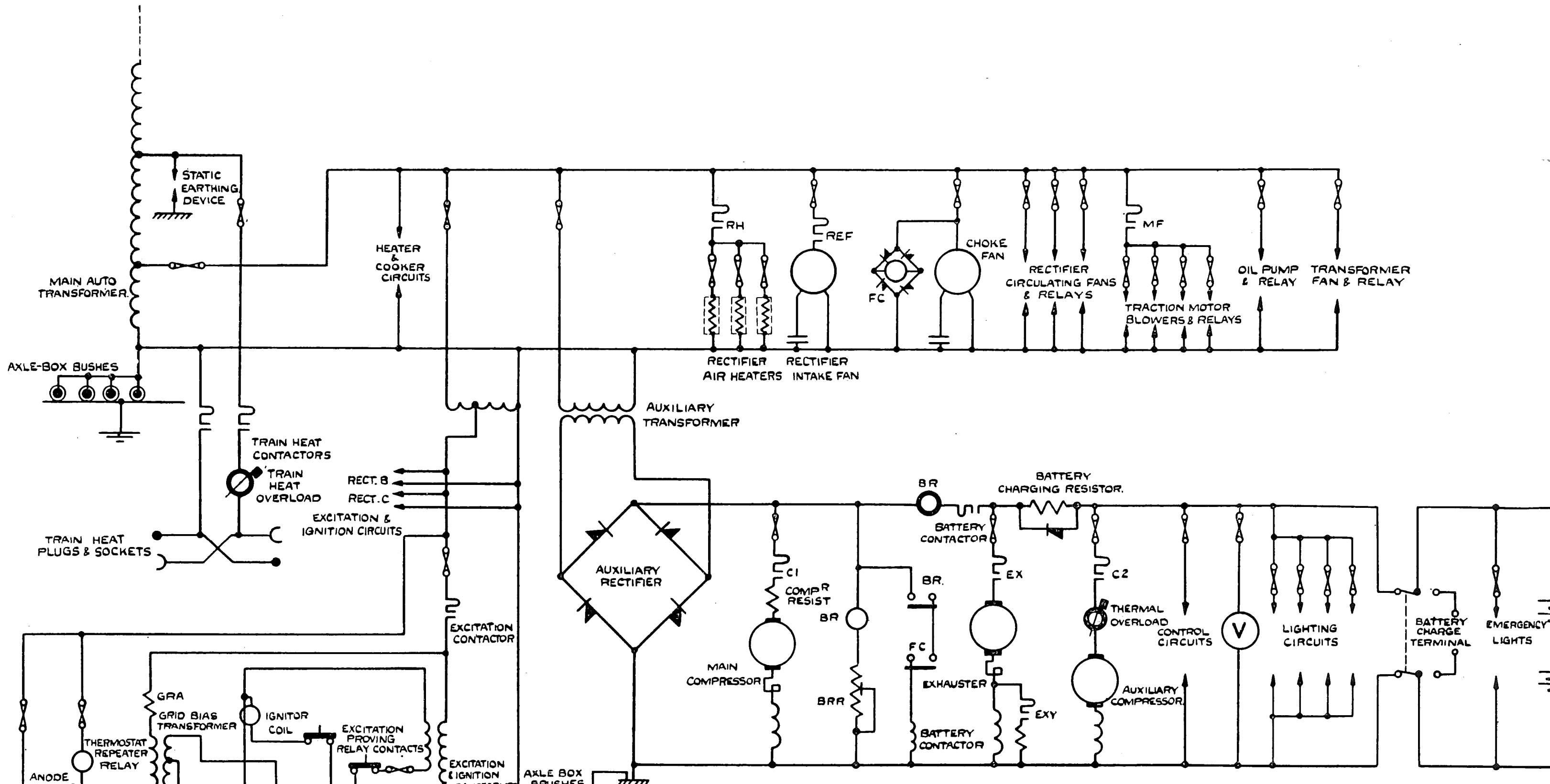



TABLE OF SYMBOLS

| | | | |
|---|---|---|---|
| C1. | MAIN COMPRESSOR CONTACTOR | | |
| C2. | AUXILIARY COMPRESSOR CONTACTOR | ERI | EXCITATION RESISTORS |
| EX | EXHAUSTER MAIN CONTACTOR | GRA | GRID BIAS SUPPLY RESISTOR |
| EXY. | EXHAUSTER HIGH SPEED CONTACTOR | THL | RECTIFIER TANK THERMOSTAT |
| FC | CHOKE FAN RELAY | BR | BATTERY REVERSE CURRENT RELAY |
| MF | TRACTION MOTOR BLOWER CONTACTOR | BRR | BATTERY RELAY SETTING. RESISTOR |
| REF | RECTIFIER INTAKE FAN CONTACTOR | | |
| RH. | RECTIFIER AIR HEATER CONTACTOR | | |

**Fig.5 Auxiliary schematic diagram. Nos.E.3046/55**

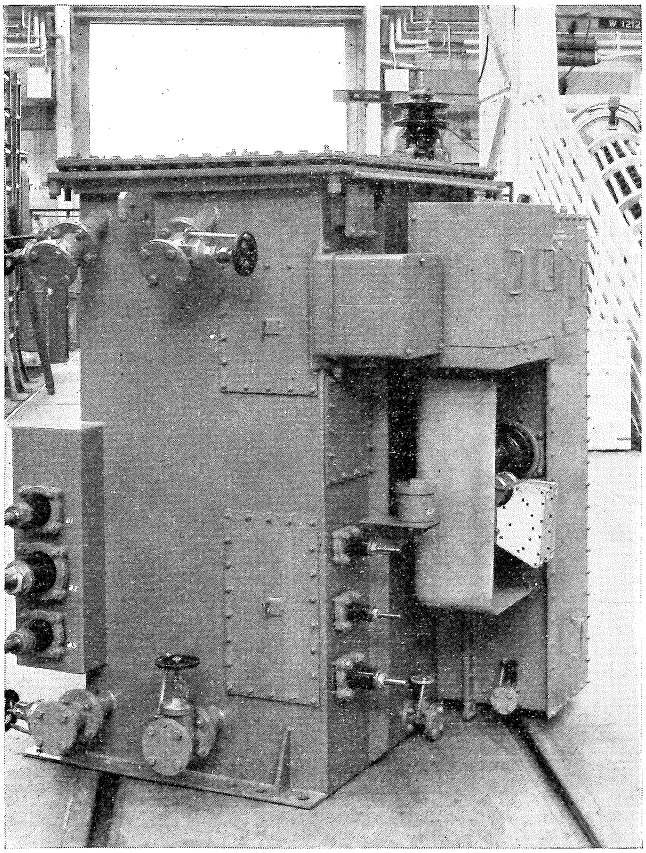


Fig.6 Main transformer. Nos.E.3046/55

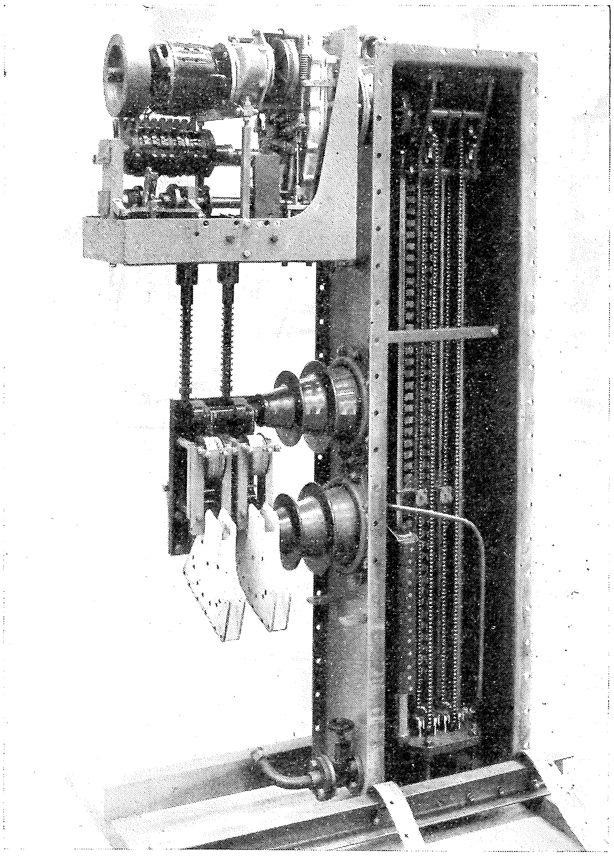


Fig.7 H.T. tap changer. Nos.E.3046/55

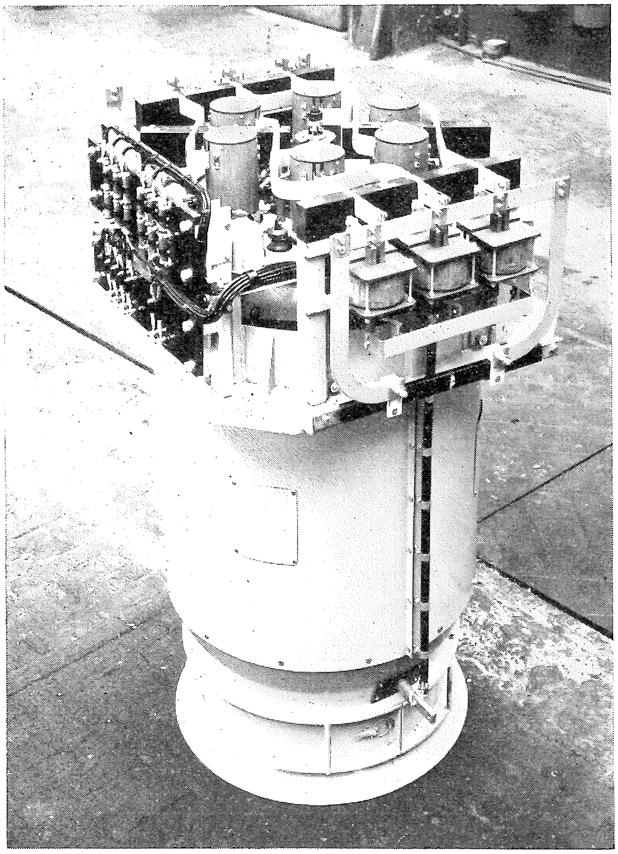


Fig.8 Multi-anode rectifier tank. Nos.E.3046/55

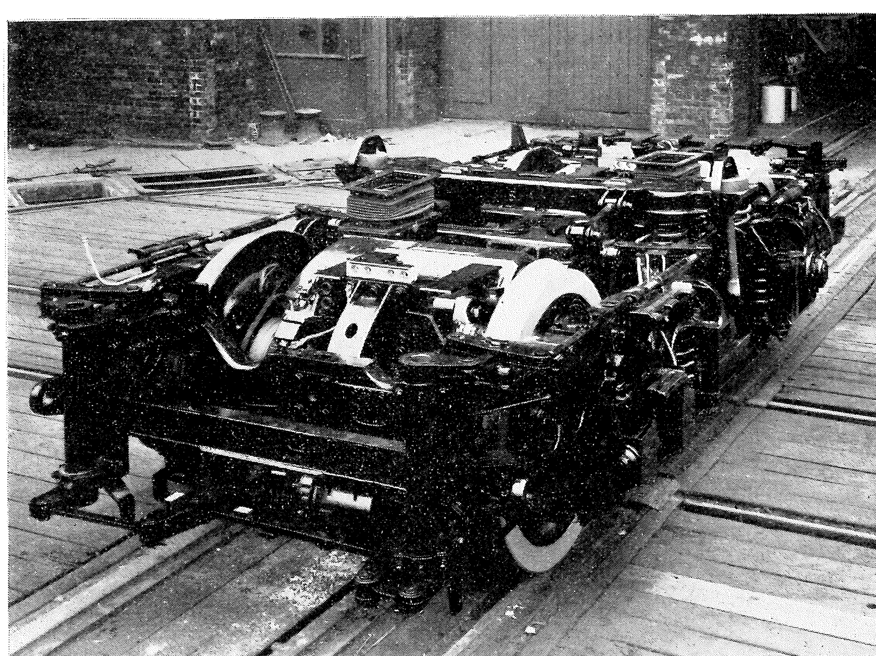


Fig.9 Bogie. Nos.E.3046/55

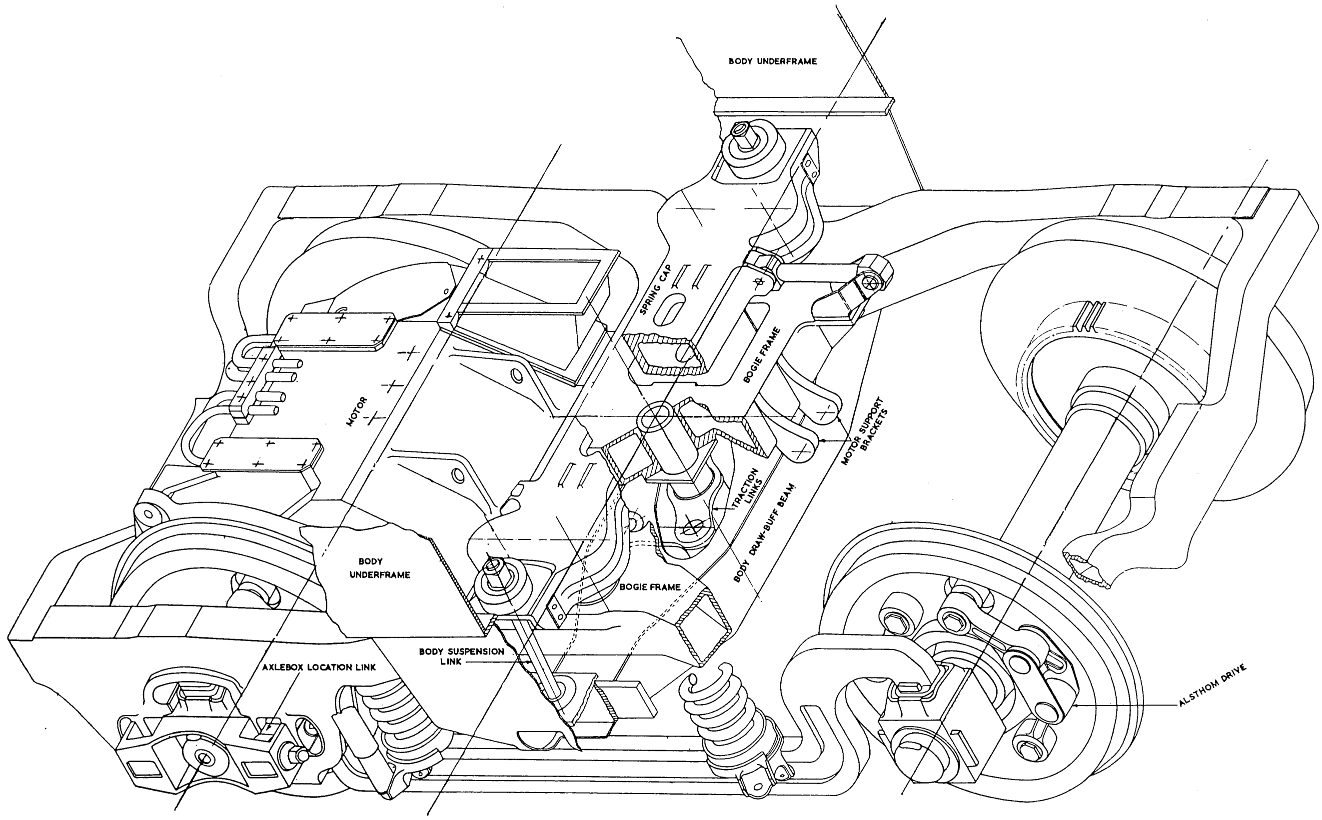



**Fig.10 Bogie arrangement. Nos.E.3046/55**

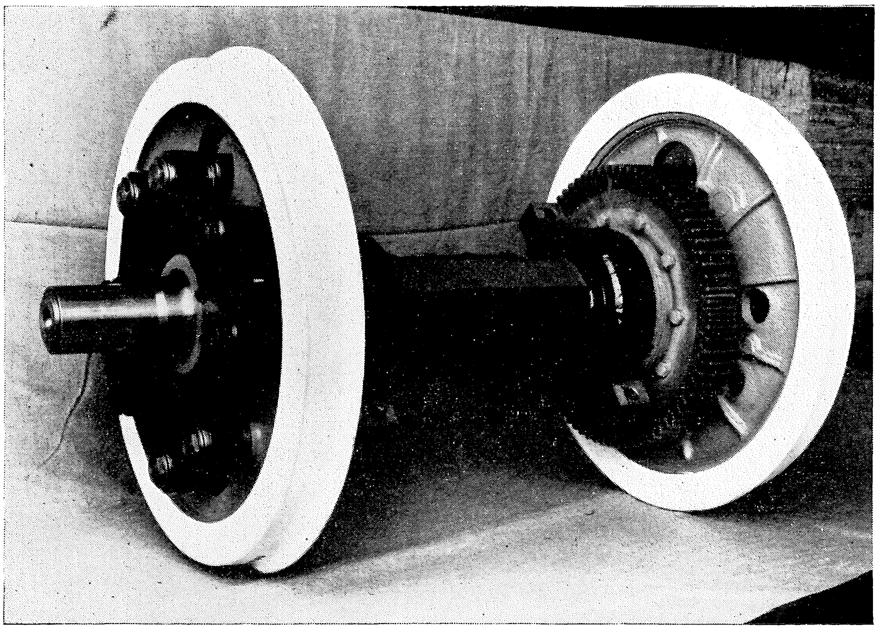


**Fig.11 Alsthom drive. Nos.E.3046/55**

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