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Paper 17

Locomotives: Nos.E 3036/45 (G.E.C.)

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1. Introduction

The paper describes the ten 50 cycle Type A locomotives ordered by the British Transport Commission from The General Electric Co., Ltd, to comply with specification AC3 of which the principal requirements are described in Paper 3. The electrical equipment and mechanical parts were designed and constructed by The General Electric Co., Ltd, and North British Locomotive Co., Ltd, respectively.

2. Leading Particulars

The locomotive is shown in fig.1.

Total weight		77 tons
Maximum axle weight		19·4 tons
Weight of electrical equipment (including drive)		38·0 tons
Weight of two bogies (excluding motors and drives)		21·0 tons
Weight of underframe and body		18·0 tons
Length over buffers		53′ 6½″
Bogie wheelbase		10′ 0″
Bogie centres		29′ 6″
Wheel diameter		4′ 0″
Gear ratio		25/74
Maximum service speed		100 m.p.h.
Maximum accelerating tractive effort (average)		48,000 lbs.
Continuous ratings:	*Full Field*	*Weak Field*
Tractive effort	21,000 lb.	17,500 lb.
Speed	54 m.p.h.	66 m.p.h.
Power	3,000 h.p.	3,080 h.p.

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

The layout of the locomotive is shown in fig.2. It is based on a single interlocked compartment containing the H.T. A.C. and rectified D.C. equipment with duplicated rectifier and D.C. equipment frames consistent with the Duplex arrangement of the power circuits.

The locomotive regulated performance characteristic shown in fig.3 is designed to meet the performance requirements dealt with in Paper 3.

3. Description of Circuits

The power circuits are based on effective parallel connection of the traction motors with H.V. tapping on half the regulating winding of the main transformer. This system reduces the current handled by the tap changer; simplifies voltage changeover; secures improved current-speed characteristics at low speeds; provides progressive tap change with simple resistance control and with two rectifier transformer secondary windings, dispenses with the need for anode chokes. Special attention has been paid to the provisions for isolating equipment without rendering the locomotive inoperative, a feature essential to main line working.

3.1 *Power Circuits*

These are shown in fig.4*a*

Power is taken from the pantograph and isolating links via the air blast circuit breaker (ABB) to the 25 and 6·25 kV connections of the changeover switch. Each incoming connection embodies a current transformer and associated overload relay. The main A.C. feeds continue to the regulating winding of the main transformer which is connected to earth at the 4 axlebox earth brushes through a negative link.

Alternate connections from 19 of the main tap changer selectors are made to the ends of the tapping resistor through the A and B divertor units. C and D units are connected across the resistance, a typical control sequence being shown in fig.4b. This provides 38 voltage control notches, odd notches only having the tapping resistor in circuit.

The regulated voltage supplies the main rectifier transformer primary via a $\pm$ 5 per cent compensating tap. The two secondary windings feed the 16 rectifiers which form two bridge circuits, each supplying two traction motors. The motor mid points are connected to earth through an earth fault relay and to the mid points of the secondary windings. This arrangement provides facilities for isolating a single motor or bogie pair of motors. Each motor leg has an overload relay and E.P. contactor on the rectifier side and a main choke, E.P. reverser, E.P. contactor and ammeter shunt on the earth side. A permanent resistive divert is connected across the motor field. The two stages of field weakening are obtained by diverting the whole field by means of E.P. contactors.

The notch indicators are fed from the secondary of a transformer which has its primary winding connected across one rectifier transformer secondary winding.

3.2 *Auxiliary Circuits*

Fig.5 shows the auxiliary circuits diagrammatically

Auxiliary supplies are derived from the auxiliary winding on the main transformer and the 80 ampere hour 110V nickel-iron battery. The former supplies the following:—

(*a*) 800 volts train heating.
(*b*) 510 volts motor generator blower sets.
(*c*) 240 volts cab heating, rectifier and transformer pumps and rectifier auxiliaries.

The D.C. services are shared between the 2 generators in conformity with the Duplex nature of the locomotive, essential supplies being available from either machine. One exhauster is run from the battery to maintain vacuum when crossing neutral sections.

4. Description of Electrical Apparatus

This section includes descriptions of the rectifiers, transformer, motor chokes and traction motors which require direct or indirect air cooling. Duplicate cooling circuits have been adopted to match the duplex nature of the electrical connections, and, by using cooling equipment in series to reduce the overall air requirements and simplify the locomotive body and ducting designs. Each of the two blowers draws air through a rectifier radiator and delivers it through three ducts, one to each of two traction motors and the other to the associated motor chokes and one half of the transformer radiator.

4.1 *H.T. Lead-in and Cable*

A solid copper connection is taken from the hollow copper roof bus-bars to a 33 kV air-to-air bushing. The connection between the bushing and the supply changeover switch is by twin 4067/·0076 P.V.C. insulated cables. Both ends of the internal connections are heavily wrapped to prevent flashover to earth under surge voltage conditions.

4.2 *Main Transformer*

General Construction

The basis is a 3-leg core of grain orientated steel laminations. One outer leg carries the regulating auto-transformer and auxiliary supply winding, the other the two windings of the main rectifier transformer. The centre leg carries only the flux difference between the outers. This arrangement of narrow oval plan section permits the transformer to be mounted ideally along the locomotive length to take the major accelerations in the direction of maximum strength. The core and coils are supported from extended core clamps which form the mounting points in the locomotive body.

The transformer tank is simply an oil container and projects below the locomotive floor. The tap changer is mounted on the tank and completes the assembly, as shown in fig.6. Special key bars and core clamps relieve the core bolt insulation from mechanical stresses and all connections and leads are held rigidly in non-shrinking insulating clamps with adjacent cables interleaved with webbing tape.

Cooling

The cooling arrangements and electrical design are largely dictated by the short time overloads of 10-15 minutes duration obtained during the most adverse locomotive starting conditions. High cooling oil velocities with circulation directed onto the appropriate surfaces are vital to achieve acceptable thermal gradients between the windings and oil. These velocities are much greater than those in static transformers and provide a useful saving in winding copper.

The oil is circulated upwards through the transformer by a motor driven pump and is cooled in a heat exchanger by air from the two motor generator blower sets.

Windings

The regulating auto- and rectifier transformers have orthodox concentric coils arranged to avoid shrinkage and consequent looseness. Class H insulation has not been employed since the winding and oil temperatures are limited by the proneness of the specified mineral oil to sludging.

Rating

The rating has been based on both starting and maximum anticipated duty cycles and provides a continuous rating corresponding to 90 per cent of the traction motor rating; i.e. 3,490 kVA and 3,060 kVA at 22·5 kV line volts for the regulating and rectifier transformers respectively. This takes into account the difference in time constants between main transformer and motors, the reactance and efficiency at this rating being 13·9 per cent and 97·75 per cent respectively.

4.3 *Tap Changer and Changeover Switch*

Tap Changer

This is a combined tapping and divertor contact unit, driven by a 110V D.C. machine with 30:1 reduction gear and magnetic clutch.

The main driving shaft is positively located by two star-wheels engaged by electro-pneumatically operated pawls which lift alternately. The drive continues to a worm reduction gear of 10·5:1 ratio giving a direct drive to the divertors and geared drive to the selector and interlock shafts.

The selector shaft carries the 20 cams for the appropriate voltage taps. The contact elements are spring-closed cam-opened and are oil immersed. Load is broken on two of the 4 cam operated link driven air-break divertors. These are fitted with laminated magnetic blowout systems and are chutes and are mechanically sequenced with the selectors to ensure that these neither make nor break current.

In notching, a feed to one pawl air engine causes the locating pawl to lift clear of its star-wheel. Pawl interlocks energise the motor and magnetic clutch causing the main shaft to rotate. During movement to the next notch, the selector shaft interlock causes the same pawl to be de-energised. This pawl drops into the star-wheel at the next notch, its interlock breaking the supply to the motor and clutch. Both pawls when down mechanically locate the shaft in this position.

Changeover Switch

This is an off-load oil immersed 3 element unit, two elements in parallel being used for 6·25 kV and one element for 25 kV working. It is a simple changeover device and is driven by two vertical E.P. controlled air engines. The assembly is mounted on the tap changer with which it forms a common oil chamber at the end remote from the drive and divertors. The main H.T. feed enters the switch via suitable bushings.

D.C. Switches

Two identical E.P. contactors of conventional D.C. design are provided in each traction motor circuit. They incorporate two pairs of contacts to deal with the heavy currents and are rated at 1,000 volts, 900 amps at 30 per cent ripple. Extension arc chutes are not fitted.

4.4 *Rectifiers and Rectifier Auxiliaries*

General

Notwithstanding its worldwide application in many forms, the pool cathode mercury arc rectifier has suffered from certain limitations resulting in rectifiers being larger and less efficient than need be. These have been resolved in the Compak rectifiers in which the cathode spot is anchored to the inner periphery of a circular cathode trough and the whole vessel including the anode is intensely cooled. Thus, the anode is no longer subject to vapour blast effects and can be brought close to the cathode, thereby considerably reducing the arc drop and heat losses. The intensive cooling enables the vapour pressure of the mercury to be controlled under all conditions of load, and makes large volumes and cooling surfaces unnecessary. The result is an efficient, compact, sealed steel tank liquid cooled excitron.

Construction

The Compak rectifier is shown in fig.7. It has a cathode structure of special steels and other materials forming a shallow dome surrounded by an annular trough and outer insulated wall. Anti-splash baffles in the base of the cathode trough minimise the effect of mercury swill. The assembly and associated ignition and excitation elements are welded to the 9 in. diameter cylindrical tank. Cooling coils are welded on the outside of the tank and de-ionising grids in the arc path are fitted internally. The top plate carrying the main and excitation anode systems, pumping connections and Pirani gauge is welded to the tank.

The main anode system comprises a metal structure attached to a co-axial tubular stem supported by a glass insulator forming the anode seal. The whole top plate assembly is encased in a fibreglass cover which protects the projecting fittings and prevents mercury condensation in the anode region.

Cooling

The Duplex circuit arrangement allows the 16 rectifiers to be mounted in 2 eight-tank frames with their associated excitation equipment. Two cooling circuits are used per frame, one for the tanks and cathodes, the other for the anodes. The coolant is a mixture of de-ionised water to which has been added Glycol as an anti-freeze agent and Nambit as an electrolysis inhibitor. It is circulated by ¾ h.p. capacitor start-and-run A.C. motor pumps, 2 per frame, and is passed through the two separate sections of the continuously cooled heat exchanger. The two heat exchangers are separately provided with a header tank and sight level gauge and are mounted one in each blower air intake. Immersion heaters are fitted in the anode cooling circuits and are controlled by thermostats to provide the correct range of coolant temperature during preparation for service. A 'Serkstat' is fitted across each section of the heat exchangers to control the coolant temperature in the anode and cathode circuits during running.

The cathode coolant circuits differ from the anode circuits in that there are no immersion heaters or controlling thermostats but there are maximum coolant temperature thermostats.

Connections between rectifier cylinders and coolant manifolds are by means of Neoprene hoses.

Excitation

The rectifiers are excited in groups of 4 cylinders to enable any traction motor to be isolated. Each group has a common 240V transformer with individual 50V secondaries for each cylinder. A solenoid operated ball mechanism provides a mercury jet to bridge the cathode/excitation anode gap, the consequent D.C. current operating the excitation relay and breaking the supply to the ignition solenoid. An A.C. choke maintains a constant excitation current and a D.C. choke of sufficient inductance provides continuous burning of the arc.

The same 50V A.C. supply is used to feed a small top plate heater clamped to the base of the main anode seal to maintain the correct temperature distribution.

Rating

In this application, each rectifier is rated at 250 amps average D.C. current, 850 volts.

4.5 *Chokes*

Motor Smoothing Chokes

These are of the laminated core, air gap, 2-leg type with Class B insulated windings. One leg carries the winding associated with one motor. The two chokes are mounted one in each of the air ducts to the transformer radiator. The motor ripple current is limited to 30 per cent at the motor 1 hr rating – the choke inductance being 4·63 mH – the ripple gradually increasing to 40 per cent under starting conditions.

The circuits adopted eliminate the need for anode chokes.

4.6 *Master Controller and Method of Control*

The master controller is of conventional butt silver contact cam operated design to provide the specified control technique and handle positions described in Paper 3.

4.7 *Traction Motors and Flexible Drives*

These are 6-pole series, lap-wound force ventilated with Class H insulation for all windings. Each frame is fabricated and fitted with an internal laminated ring bridging between the laminated main poles and interpoles. Compensating windings carrying the full armature current are accommodated in the main pole faces providing increased stability under transient conditions, minimum frame diameter and minimum field copper. All components in the field assemblies tending to attenuate the interpole flux ripple and alter its relationship to the armature current have been eliminated. The main field flux ripple, and hence transformer E.M.F. are considerably reduced by means of a permanent resistive field divert. The full field continuous rating is 725 amps, 850V the armature peripheral speed at 100 m.p.h. being 12,000 ft/min with half worn wheels.

The motor is mounted at three points in the bogie frame and supports the short hollow quill and spring gearwheel of the Brown-Boveri drive. This is a 5° angle helical reduction gear, oil lubricated, with a 25:74 ratio. The spring loaded pads in the gearwheel engage with, and drive through, a star wheel integral with the axle.

4.8 *Auxiliary Machines*

The nature and performance of these are as under:—

No.	*Function*	*Capacity*	*Drive*	*Rating*	*Speed*
1	Auxiliary compressor	5 c.f.m.	D.C.	¾ h.p.	1,050 r.p.m.
1	Main compressor	40·3 c.f.m.	D.C.	9 h.p.	1,000 r.p.m. compressor; 3,000 r.p.m. motor
2	Exhausters	66 c.f.m.	D.C.	3·0 h.p.	600 r.p.m.
		132 c.f.m.	D.C.	6·4 h.p.	1200 r.p.m.
2	M.G. blowers	11,000 c.f.m.	A.C.	42 h.p.	2,960 r.p.m.
			D.C.	10 kW	
1	Transformer oil pump	48 c.f.m.	A.C.	4 h.p.	1,450 r.p.m.
4	Rectifier coolant pump	1·4 c.f.m.	A.C.	¾ h.p.	2,860 r.p.m.

The two M.G. blower sets are started in sequence from the battery using the generator as a motor. Each machine runs up to two-thirds speed before being connected to the A.C. supply by a timing relay. Only the generator of the set supplying the battery and its associated equipment is voltage regulated although the regulator and essential services can be transferred to the other set in an emergency.

5. Protection

Power Equipment

The air blast circuit breaker is tripped by the following:

(*a*) Current transformer operated overload relays in the 25 and 6·25 kV connections to the regulating transformer.

(*b*) An overload relay in the earth end of the rectifier transformer primary circuit.

(*c*) A mid point earth fault relay.

(*d*) A single float Bucholz relay.

(*e*) A time delay relay protecting the tapping resistance and regulating winding against short circuits due to a supply failure to the tap changer mechanism.

Individual traction motor overload relays protect against heavy notching overcurrents. These are over-ridden by a single motor overcurrent relay designed to arrest the notching sequence on 'run-up' until the traction motor current falls with increasing locomotive speed to a predetermined value.

A surge divertor is connected across the tapped section of the regulating transformer to limit the surge voltage at the open circuited 25 kV terminal when in the 6·25 kV connection to less than the chopped wave impulse test voltage. In the 25 kV connection, a surge appearing at the divertor would be insufficient to cause it to operate.

Auxiliary Equipment

Individual A.C. and D.C. circuits are protected by H.R.C. fuses. Thermostats are provided to protect the motors of the motor generator blower sets.

6. Mechanical Parts

6.1 *Bogie*

The construction of the bogies is shown in fig.10.

The 2-axle bogie frame is a stress relieved fabricated box section structure made up of ⅜ in. (9·52 mm) steel plate and welded.

The weight of the locomotive structure is transferred to the two bogies by pillars, two per bogie which extend from the body to the bolster. These pillars terminate in spherical shaped steel bearings to which are fitted manganese pads which in turn bear on manganese pads on the bolster. Each unit is in an enclosed oil bath thus ensuring full lubrication to the bearing surfaces.

The load is transferred to the bogie (at each end of the bolster) by two nests of double coiled helical springs. These springs are carried on a bracket suspended from the bogie by swing links, which terminate in rubber bonded pads. Working in conjunction with these links are hydraulic dampers so that the bolster is sandwiched between the rubber ended swing links and hydraulic unit. Lateral movement of the bolster is controlled by rubber pads of two different hardnesses.

Tractive braking and transverse forces from the rail are transmitted through a steel pivot pin fixed to a steel casting in turn welded to the main frame. The pivot pin enters the bolster in a bonded rubber bush and the tractive and braking forces are transmitted to and from the bolster and the bogie frame by forged steel traction links, rubber bushed, $22\frac{1}{4}$ in. (565 mm) above rail level.

Cast steel axleboxes are fitted with grease lubricated roller bearings. The axlebox wearing surfaces are faced with manganese steel liners and no lubrication is provided. The load from the bogie frame to the axle bearings is taken by two nests of coil springs at each end of the axle through links and a compensating beam which rests on the axlebox. Rubber pads are fitted at the top and bottom of the springs.

The static deflection figures for primary and secondary suspension are $2\frac{1}{2}$ in. and $3\frac{5}{8}$ in. respectively.

The whole bogie design has been the subject of an intensive study using computers to determine the riding characteristics.

6.2 *Main Frame*

In order to withstand the direct buffing load and considerable bending moment within the special weight restrictions, the full height of the body sides has been employed using a girder frame on the Vierendeel principle. The bending moment is transferred to the full height between the side windows and door through vertical pillars allowing a gradual transition from point loads at the buffer beam, as shown in fig.11. Furthermore, substantial members are lead up from the beam at the cab corners to tie up to the pillars to provide the basis for safety protection for the driver.

The frame can be visualised as a number of U-shaped box sections which form vertical pillars and stretchers connected longitudinally at their bases by the underframe longitudinals and at their tops by a cantrail. This depends for its strength on the stiffness of the joints and generous radii are provided between the vertical pillars and the cantrail and underframe.

As all welding is fillet welding, there are no butt welds in tension.

The underframe is of box section with a flush skin. The outer plate at the base of the 'U' is left continuous on the underside presenting a clean smooth surface below the frame. To provide access for welding, holes are cut in the top plate of the underframe with generous radii giving access to the cellular compartments formed by the longitudinals and transverse ribs.

The whole frame is constructed from 7 SWG (4·47 mm) mild steel plate with a maximum carbon content not exceeding ·20 per cent but in the area of the fabricated dragboxes, the thickness is increased to $\frac{3}{8}$ in. and $\frac{3}{4}$ in.

This form of construction has produced a monocoque structure and in view of the novel features, the whole design was carefully stress analysed. Finally one bare structure was loaded in a special frame and submitted to an end test load of 230 tons. More than one hundred strain gauges were placed at the more highly stressed points on the structure and deflection readings were taken using clock gauges and piano wire. No troubles whatever were experienced, the structure proved entirely elastic and after each loading cycle the frame returned to its original position.

6.3 *Braking System*

The locomotive is fitted with independent and vacuum controlled air brakes. Four cylinders on the bogie operate the brake gear through a simple lever arrangement with slack adjusters incorporated in the system. The slack adjusters take up the full wear of the brake blocks irrespective of the tyre diameter. An anti-slip brake is also provided under the driver's control.

A hand brake is arranged to couple up to the brake linkage on one axle. It is operated by hand wheel in the cab through a chain and cardanshaft arrangement.

7. Conclusion

The locomotives described above are the outcome of an exhaustive study of all aspects of design and construction using the extensive resources of the two Companies. Special attention has been paid throughout to weight saving and all the equipment has been subjected to thorough development and prototype testing before being put into service. Further developments are well in hand to increase the ratings of rectifiers and transformers, schemes have been evolved for the application of semi-conductor rectifiers and dynamic braking and means of simplifying the schemework, auxiliaries, manufacturing techniques and many other facets are under constant review.

SUMMARY

This paper describes A.C. 50 cycle locomotives built for B.T.C. by The General Electric 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 3,080 h.p., can operate on a 25 kV or 6·25 kV supply and weigh 77 tons.

Power conversion from 50 cycle single phase supply to an undulating unindirectional current for the D.C. traction motors is by means of 16 mercury arc water cooled sealed steel tank excitrons connected to form two bridge circuits each supplying two traction motors.

Regulation of power is by a 38-step motor driven tap changer on the high tension side of the main transformer which comprises a regulating auto-transformer with multiple tappings and a rectifier transformer, both in one tank. The main transformer, tap changer selectors and associated changeover switch are oil immersed; the four tap changer diverters are air break, two diverters performing all the make-and-break duties.

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

Two A.C.-driven motor generator blower sets provide all the cooling air requirements and the 110V D.C. supplies for the compressor, exhausters and battery charging. The auxiliaries such as transformer oil and rectifier coolant pump motors are single phase capacitor start-and-run induction motors.

The traction motors are bogie mounted and drive their respective axles through Brown-Boveri flexible couplings.

The body is carried on the two fabricated box section bogies through pillars and spherically-seated oil lubricated bearers on to the bolster. This is supported through nests of double coiled helical springs on a spring blank suspended from the bogie through swing links. Primary springing at each axlebox consists of two nests of coil springs with links and compensating beam. A low traction point between body and bogie minimises weight transfer.

The superstructure is of mild steel stressed frame construction and has been statically tested using strain gauges under an end loading of 230 tons.

The weight of the electrical equipment and mechanical parts of the locomotive are 38 and 39 tons respectively.

RÉSUMÉ

Cet exposé décrit les locomotives à courant alternatif 50 Hz construites pour la British Transport Commission par la General Electric Company Ltd.

Ces locomotives du type "Bo-Bo" possèdent chacune deux cabines de conduite. Le rapport d'engrenages est choisi pour la vitesse maximum de 100 m.p.h. Leur puissance nominale, au régime continu, est de 3330 h.p. Elles peuvent fonctionner sous 25 kV ou 6,25 kV et pèsent 77 tons.

La conversion du courant monophasé 50 Hz en courant ondulatoire unidirectionnel pour les moteurs de traction à courant continu s'effectue au moyen de 16 excitrons, à cuves en acier et refroidis à l'eau. Les redresseurs sont montés en deux ponts dont chacun assure l'alimentation de deux moteurs de traction.

Le réglage de la puissance s'obtient sur l'enroulement haute tension au moyen d'un commutateur en 38 échelons, actionné par un moteur. Le transformateur principal comprend un auto-transformateur de réglage avec plusieurs prises et un transformateur de redresseurs, tous les deux se trouvant dans une seule cuve. Le transformateur principal, les contacteurs de réglage et le commutateur pour le branchement en série ou en parallèle sont immergés dans l'huile; les quatre contacteurs de rupture en charge fonctionnent dans l'air.

Un disjoncteur à air comprimé, monté sur la toiture, protège contre les surcharges éventuelles sur le transformateur principal et des défauts de mise à la terre au transformateur ou dans les circuits basse tension de traction.

Deux groupes ventilateurs, actionnés par un moteur à courant alternatif dont le lancement se fait par la génératrice accouplée, assurent l'alimention complète en air de refroidissement. Ce groupe fournit aussi la tension continue de 110 V pour le compresseur, les aspirateurs et la charge des batteries. Les appareils auxiliaires, tels que les moteurs de la pompe à huile du transformateur et celle du liquide réfrigérant des redresseurs, sont des moteurs d'induction monophasés avec condensateur pour le démarrage et la marche normale.

Les moteurs de traction sont entièrement suspendus et entraînent les essieux correspondants par l'intermédiaire d'accouplements élastiques Brown-Boveri.

La caisse de la locomotive est portée par les deux bogies assemblés, de construction en caisse, par l'intermédiaire de pivots et au moyen de supports à sièges sphériques, lubrifiés à l'huile et se trouvant sur le sommier. Ce dernier est supporté par l'intermédiaire de faisceaux de ressorts helicoïdaux doubles placés sur un plateau d'acier suspendu au bogie au moyen de coulisses. Les ressorts primaires sur chaque boîte d'essieu consistent en deux faisceaux de ressort en spirale, munis du balancier et des coulisses nécessaires. Le déchargement des essieux est réduit au minimum par le point bas d'entraînement de la caisse de la locomotive par les bogies.

La caisse est à revêtement travaillant en acier doux, lequel a subi l'essai statique à l'extensomètre et sous une charge terminale de 230 tons.

Les poids de la partie électrique et de la partie mécanique de la locomotive s'élèvent à 38 et 39 tons respectivement.

ZUSAMMENFASSUNG

Der Bericht beschreibt die im Auftrage der "British Transport Commission" von der "General Electric Company Limited" gebauten 50 Hz Wechselstrom-Lokomotiven.

Die Lokomotiven sind mit zwei Führerkabinen und Achsen des Systems Bo-Bo ausgerüstet. Die Getriebeausrüstung erlaubt eine Höchstgeschwindigkeit von 100 m.p.h., die Nenn-Dauerleistung beträgt 3330 h.p. Diese Lokomotiven, welche je 77 Tons wiegen, können an ein 25 kV-oder 6.25 kV Versorgungssystem geschaltet werden.

Die Umformung der Energie von 50 Hz Einphasenstrom in Wellenstrom für die Gleichstrom-Fahrmotoren erfolgt durch 16 pumpenlose Quecksilberdampf-Stahlgefäss-Gleichrichter vom Excitron Typ, die zwei Brückenstromkreise bilden, wovon jeder zwei Fahrmotoren speist.

Die Energieregelung erfolgt durch einen auf der Hochspannungsseite des Haupttransformators angebauten, motorangetriebenen, 38 stufigen Anzapfumschalter. Der Haupttransformator besteht aus einem regulierbaren Spartransformator mit Vielfachan-

zapfungen sowie einem Gleichrichter-Transformator, beide Geräte befinden sich in einem gemeinsamen Gefäss. Der Haupttransformator, der Anzapfumschalterwähler sowie der dazugehörige Umschalter stehen in Oel. Die vier Anzapfungs-Ableitungsvorrichtungen arbeiten unter Luftabschaltung. Sämtliche Ein- und Ausschaltvorgänge erfolgen von zwei Ableitungsvorrichtungen aus.

Ein auf dem Dach der Lokomotive vorgesehener Druckluftschalter schützt das System gegen Auswirkungen von eventuellen Haupttransformator Überlastungen sowie von Erdfehlern in Transformatoren oder Niederspannungs-Starkstromkreisen.

Die benötigte Kühlluft sowie die 110 V Gleichstromversorgung für den Kompressor, Sauglüfter und die Batterieladung wird von zwei mit Wechselstrom angetriebene Motor-Generator Gebläseaggregaten geliefert. Bei den Hilfsgeräten, wie Transformatoröl- und Gleichrichter-Kühlpumpenmotoren, handelt es sich um Einphasen Induktionsmotoren mit Anlauf- und Lauf-Kondensatoren.

Die in die Drehgestelle montierten Fahrmotoren treiben die betreffenden Achsen über elastrische Kupplungen (Brown Boveri) an.

Der Lokomotivrahmen wird mittels Säulen und oelgeschmierten Kugellagern vom Schemel und den kastenquerschnittsförmigen Drehgestellen getragen. Der Schemel ruht über Doppelspiralfedersätzen welche auf einer durch Gelenke in das Drehgestell eingehängten Stahlplatte befestigt sind. Die Hauptfederung an jedem Achslager besteht aus zwei Spiralfedersätzen mit Schwingen und Ausgleicheshebel. Durch den tief gewählten "Zugpunkt" zwischen dem Lokomotivrahmen und dem Drehgestell wird die Gewichtsübertragung verringert.

Der aus vorgespannten Flusstahlrahmen zusammengesetzte Oberteil wurde unter Verwendung von Verformungsmessern bei einer Belastung von 230 tons statisch geprüft.

Das Gewicht der elektrischen Ausrüstung bzw. der mechanischen Teile der Lokomotive beträgt 38 bzw. 39 tons.

RESÚMEN

En este tema se describen las locomotoras de c.a. a 50 ciclos construídas para la Comisión Británica del Transporte por la General Electric Company Limited.

Las ruedas de estas locomotoras están dispuestas según el sistema "Bo-Bo" y constan de dos cabinas de conducción; sus sistemas de transmisión desarrollan una velocidad máxima de servicio de 100 m.p.h. y la potencia máxima en régimen constante es de 3330 h.p. Son accionadas por una corriente de 25 kV ó 6,25 kV y pesan 77 tons.

La transformación de energía de corriente monofásica de 50 ciclos a la corriente unidireccional ondulada que exigen los motores de tracción de corriente continua se realiza por medio de 16 "excitrones" a arco de mercurio, enfriados por agua y encerrados en tanques de acero, conectados de modo que formen dos circuitos en puente, cada uno de los cuales alimenta a dos motores de tracción.

La regulación de la potencia se lleva a cabo mediante un cambiador de tomas a motor, de 38 etapas, acoplado en el lado de alta tensión del transformador principal que comprende un autotransformador regulador con tomas múltiples así como un transformador-rectificador, ambos contenidos en un tanque. El transformador principal, el selector del cambiador de tomas y su correspondiente conmutador se hallan sumergidos en aceite; los cuatro desviadores del cambiador de tomas funcionan por ruptura al aire y dos de los desviadores efectúan la función de conjunción e interrupción.

Un disyuntor enfriado por soplo de aire situado en el techo protege al sistema contra toda posibilidad de sobrecarga en el transformador principal y contra las fallas de puesta a tierra en el transformador y circuitos de fuerza de baja tensión.

Dos grupos aventadores accionados por un motor-generador de c.a. proporcionan el aire de enfriamiento requerido, así como la corriente continua de 110 voltios que necesita el compresor, aspiradores y la carga de baterías. Los aparatos auxiliares, como son los motores de bombeo para el aceite del transformador y el refrigerante del rectificador, son en realidad motores de inducción monofásicos actuados por condensador.

Los motores de tracción se hallan montados sobre bogies y mueven a sus respectivos ejes através de acoplamientos flexibles Brown-Boveri.

La caja de la locomotora va montada sobre los dos bogies prefabricados y de sección rectangular sostenidos por columnas y soportes de asiento esférico lubricados por aceite que descansan sobre el travesaño. Este último se asienta sobre juegos de resortes helicoidales dobles colocados encima de una plancha de acero suspendida del bogie por medio de eslabones pivotantes. Los resortes primarios en cada caja del eje consisten do dos juegos de resortes en espiral dotados de eslabones y barra compensadora. La transmisión del peso se reduce al mínimo por medio de un punto de tracción entre la caja y el bogie.

La superestructura consiste de un chasis hecho de acero dulce prefatigado sometido a prueba estática recurriendo al uso de indicadores de deformación bajo una carga terminal de 230 tons.

El peso del equipo eléctrico y de las piezas mecánicas de la locomotora es de 38 y 39 tons respectivamente.

Fig.1 View of locomotive in service. Nos.E.3036/45

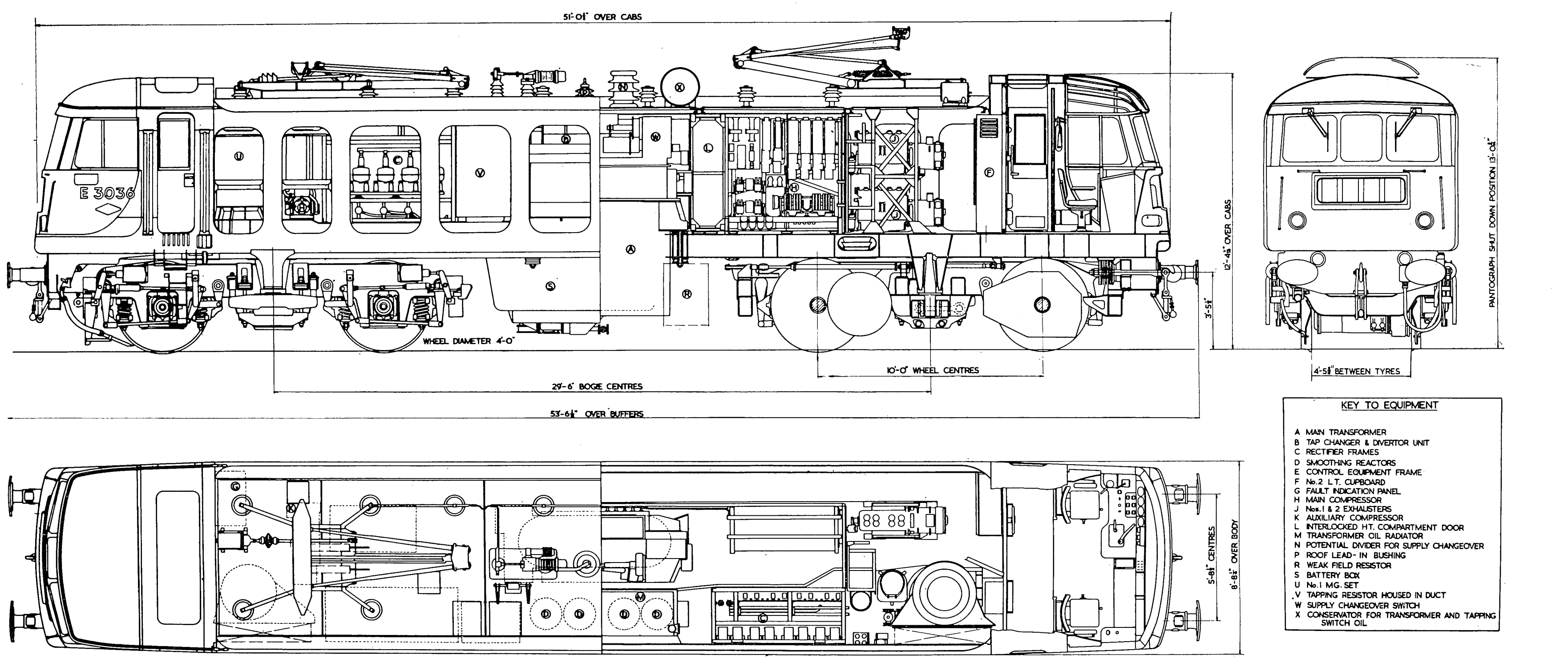


Fig.2 General arrangement. Nos.E.3036/45

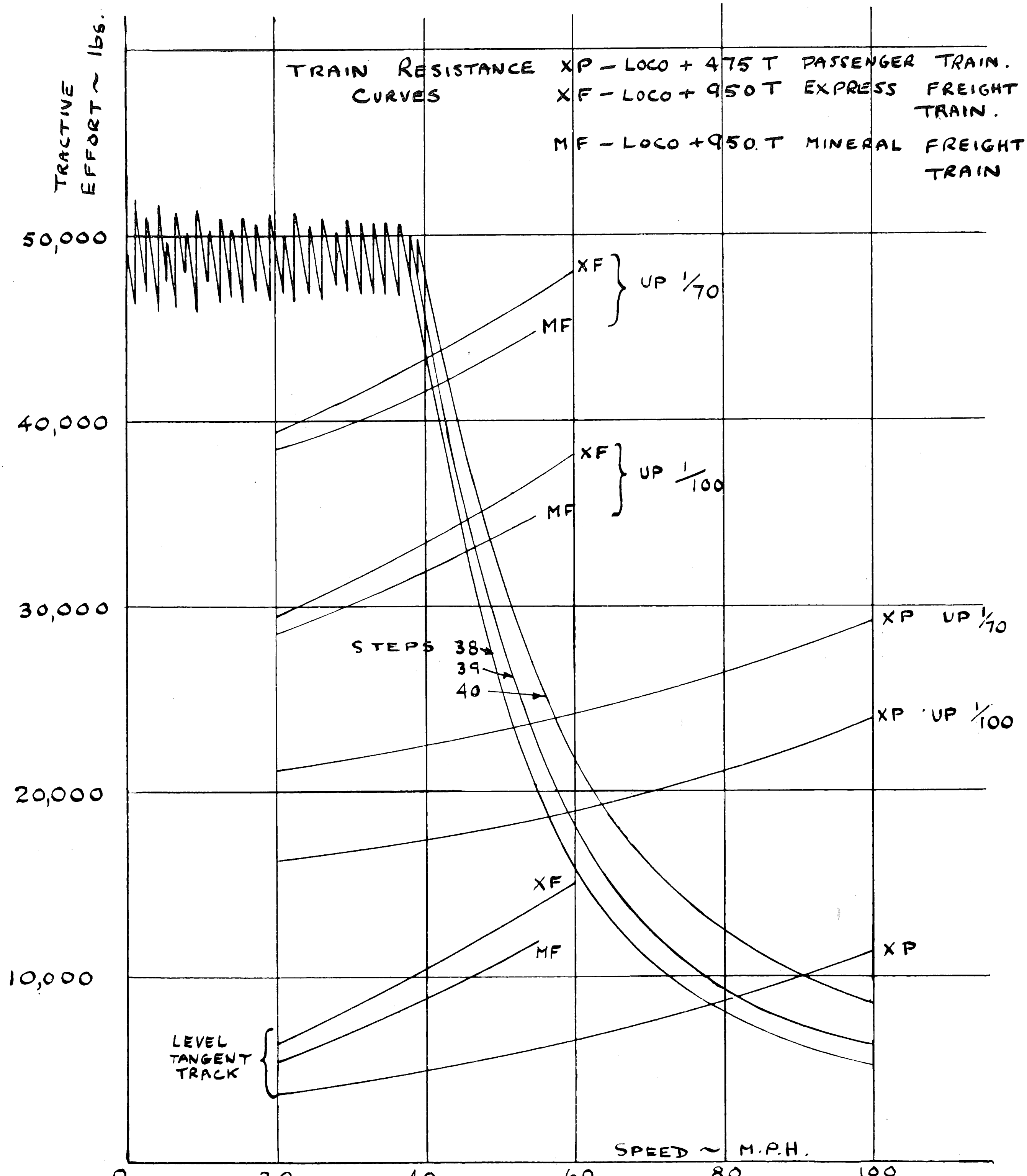


Fig.3 Performance characteristic. Nos.E.3036/45

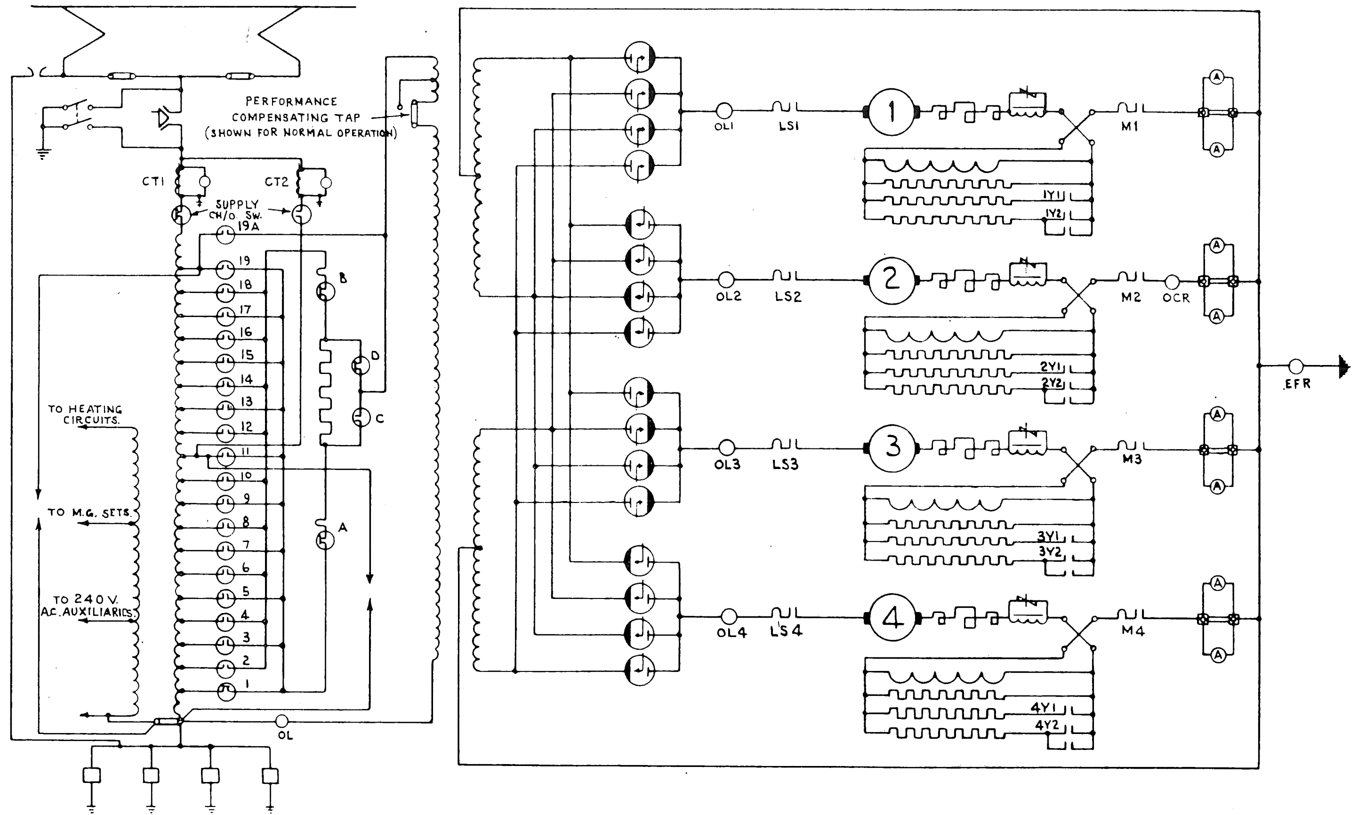


Fig.4a Diagram of main power circuits. Nos.E.3036/45

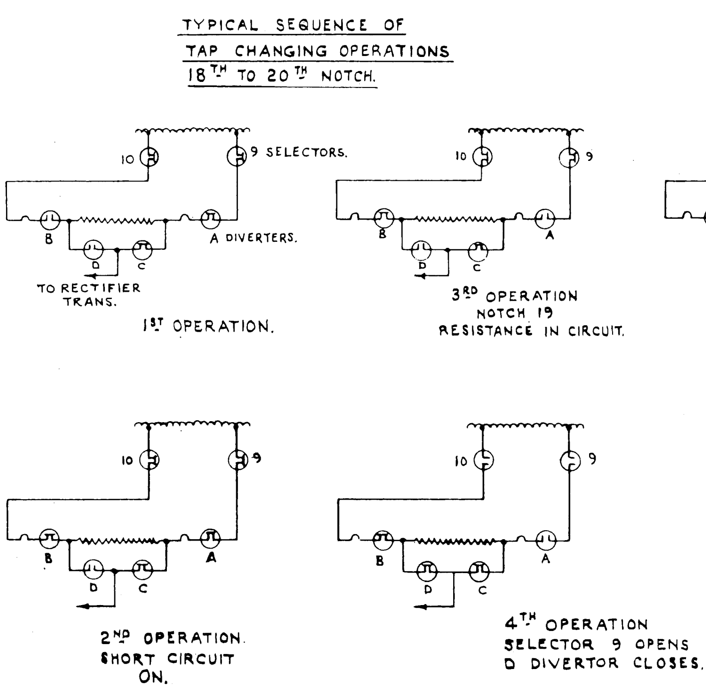
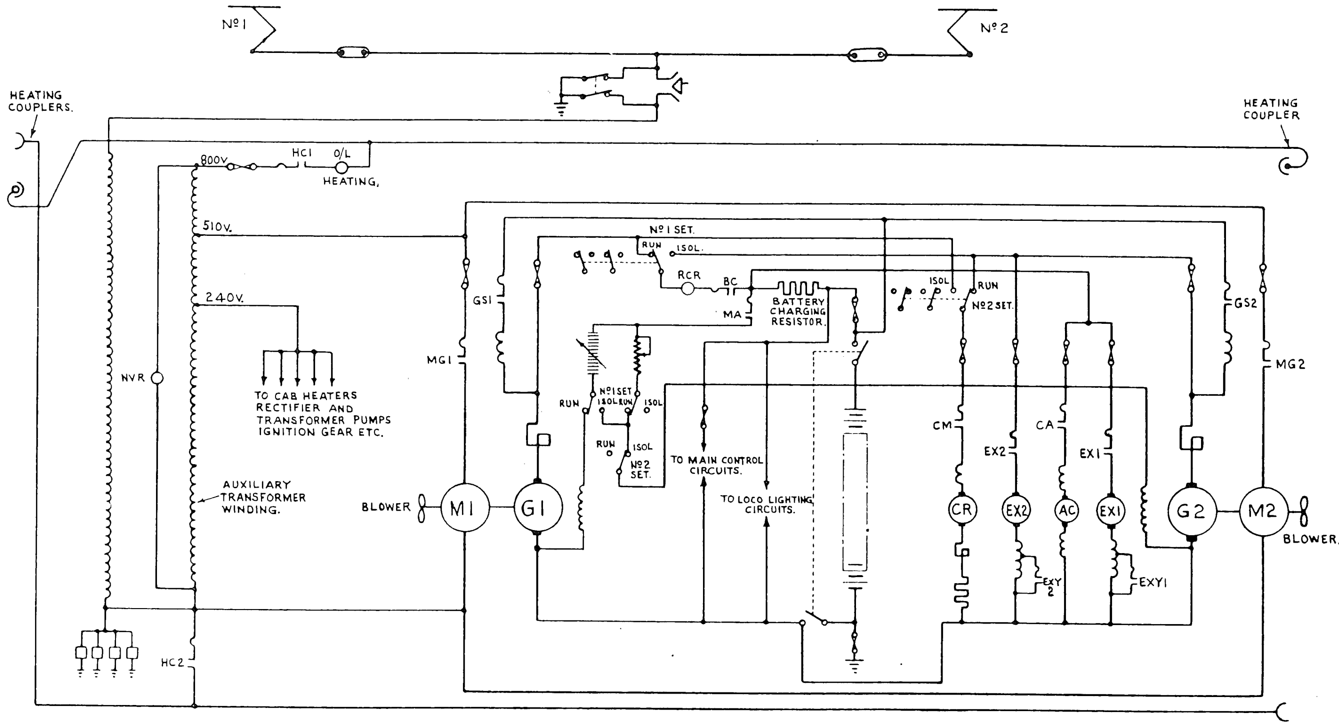


Fig.4b Tap change sequence. Nos.E.3036/45



SYMBOL	DESCRIPTION
NVR	NO VOLT RELAY.
MG1/2	A.C. MOTOR CONTACTORS
GS1/2	M.G. SET STARTING CONTACTORS.
RCR	REVERSE CURRENT RELAY
BC	BATTERY CHARGING CONTACTOR.
MA	MASTER AUXILIARY CONTACTOR.
CM	MAIN COMPRESSOR CONTACTOR.
EX1/2	EXHAUSTER MOTOR CONTACTORS.
EXY1/2	EXHAUSTER WEAK FIELD CONTACTORS.
CA	AUXILIARY COMPRESSOR CONTACTOR.
HC1/2	HEATER CONTACTORS.

Fig.5 Diagram of main auxiliary circuits. Nos.E.3036/45

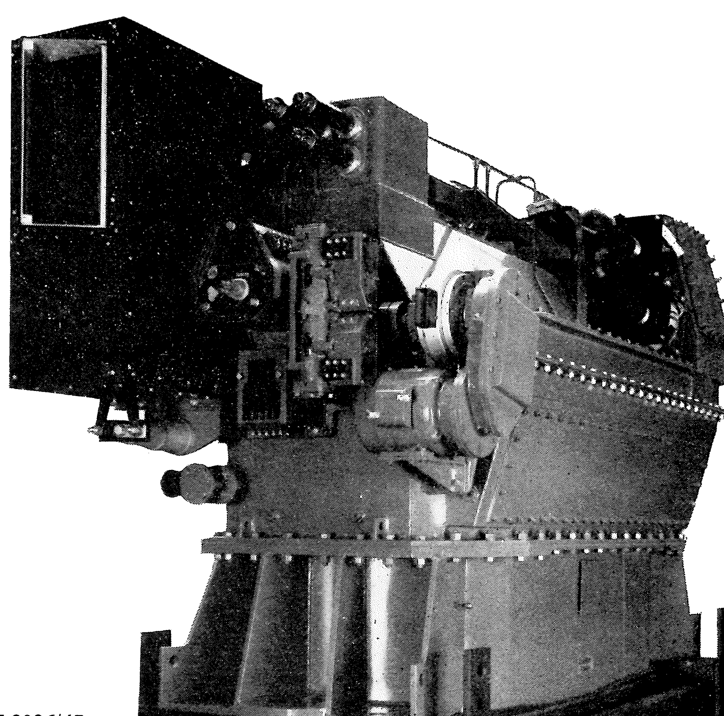
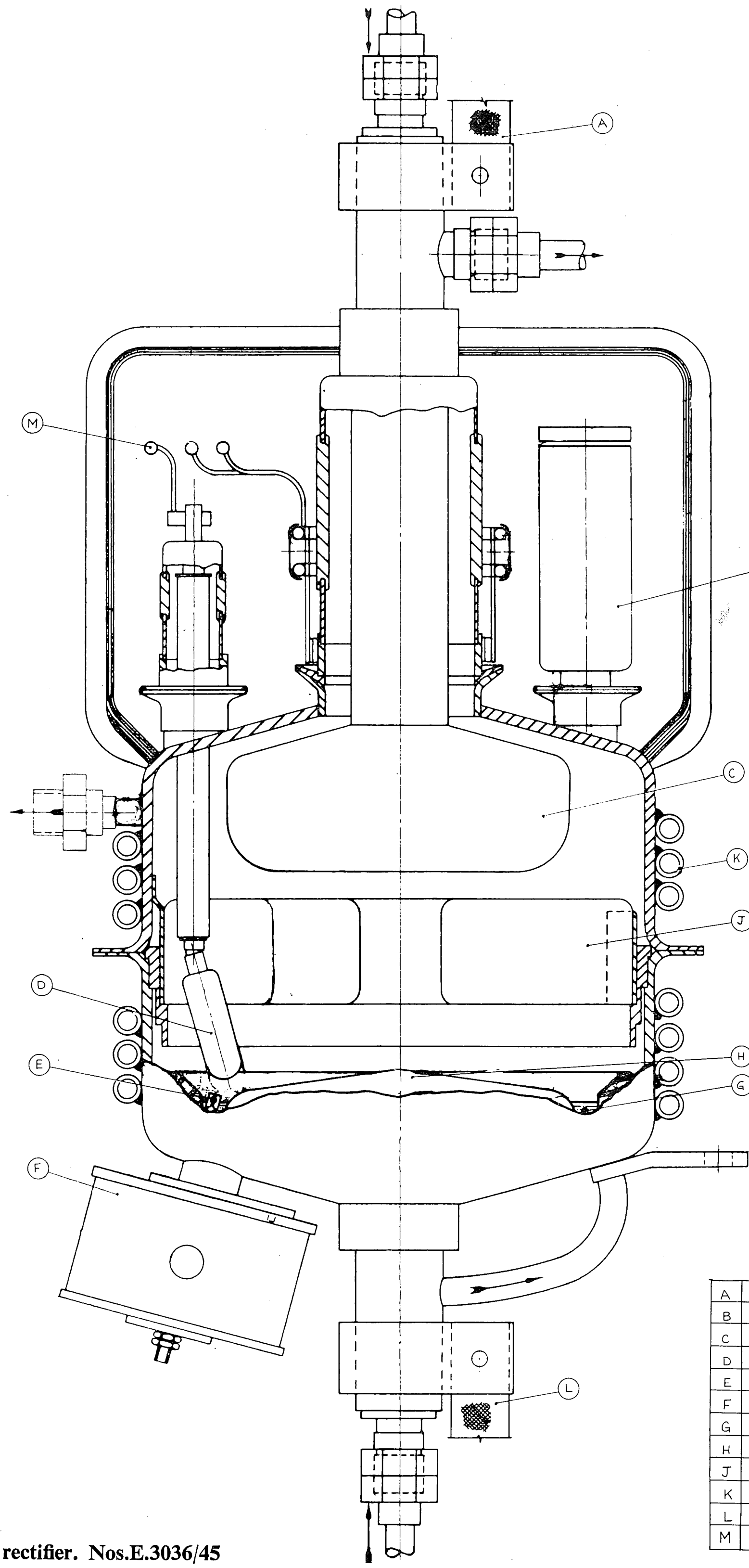


Fig.6 Transformer and tapping switch. Nos.E.3036/45



A	ANODE CONNECTION
B	VACUUM SEAL
C	MAIN ANODE
D	EXCITATION ANODE
E	IGNITOR JET
F	IGNITOR SOLENOID
G	MERCURY
H	CATHODE DOME
J	DEIONISING GRIDS
K	COOLING TUBES
L	CATHODE CONNECTION.
M	EXCITATION ANODE TERMINAL

Fig.7 GEC 9″ 'Compak' mercury arc rectifier. Nos.E.3036/45

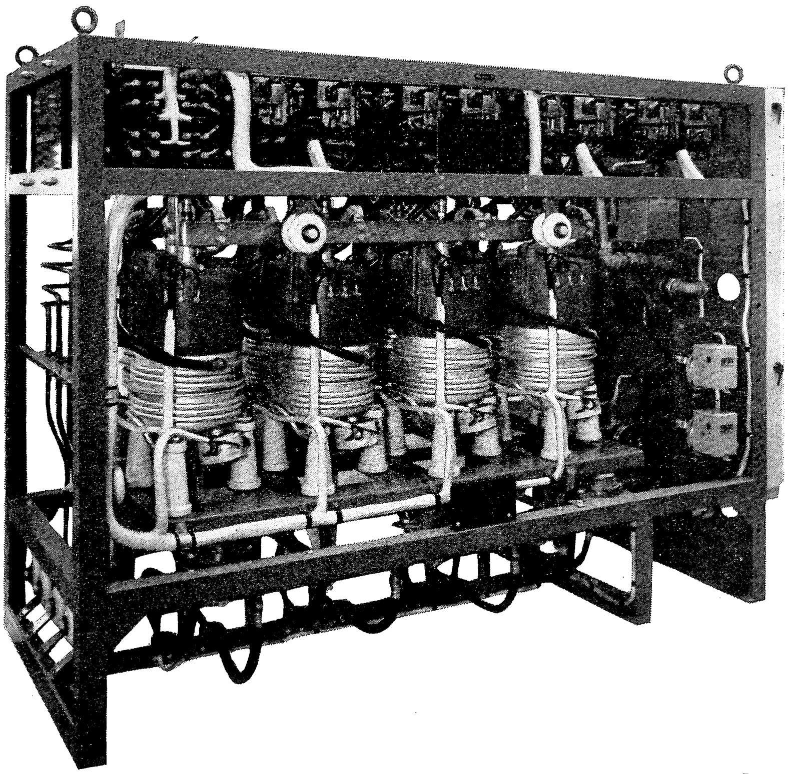


Fig.8 Rectifier frame. Nos.E.3036/45

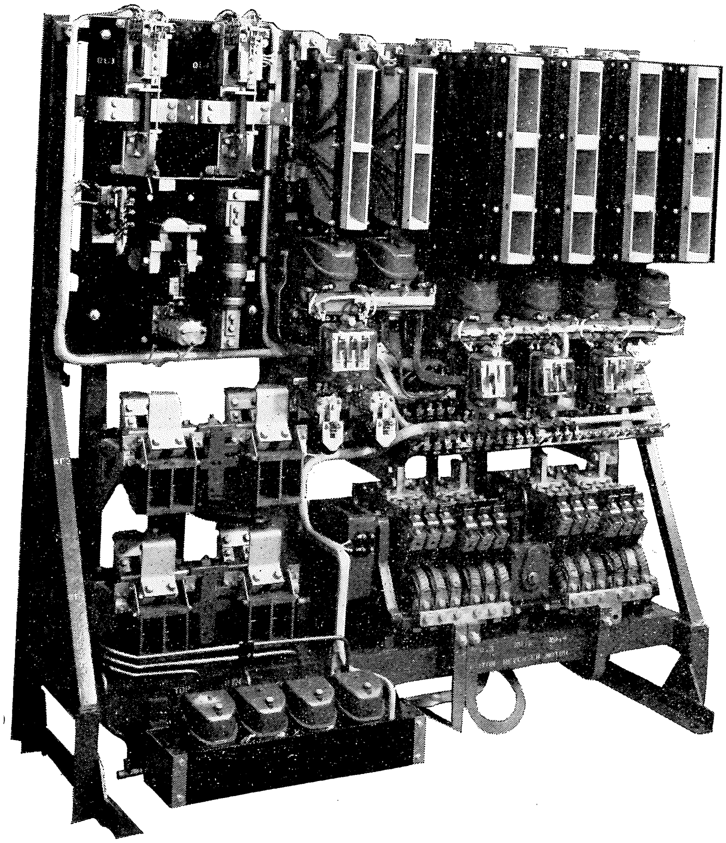


Fig.9 D.C. control frame. Nos.E.3036/45

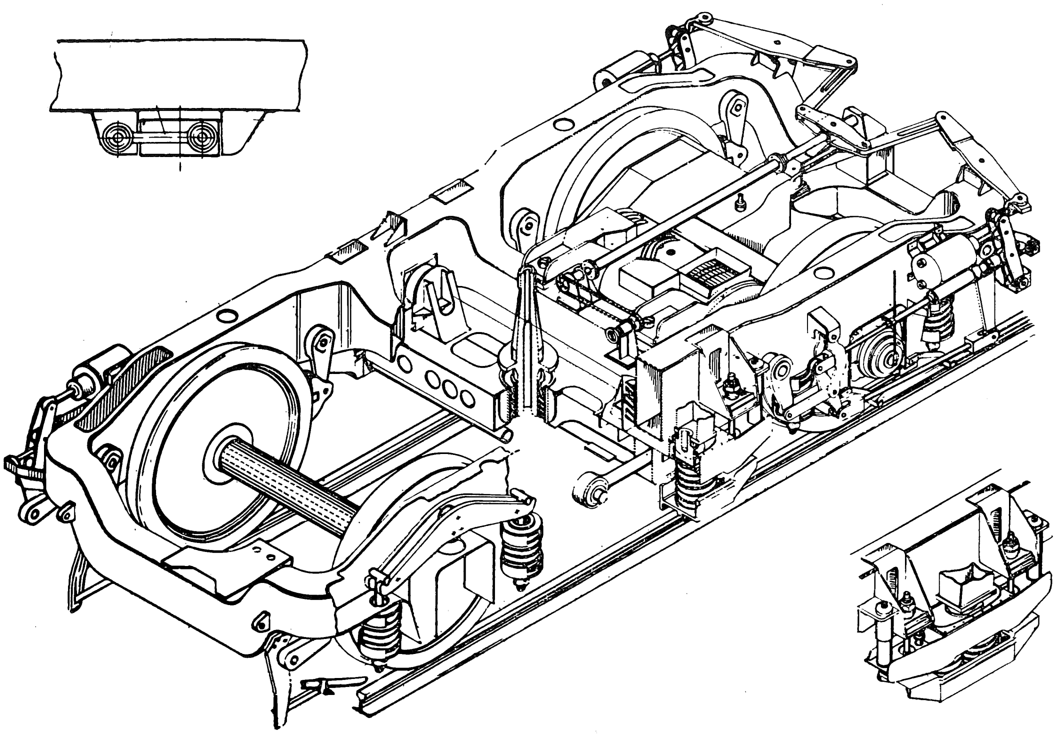


Fig.10 Arrangement of bogie. Nos.E.3036/45

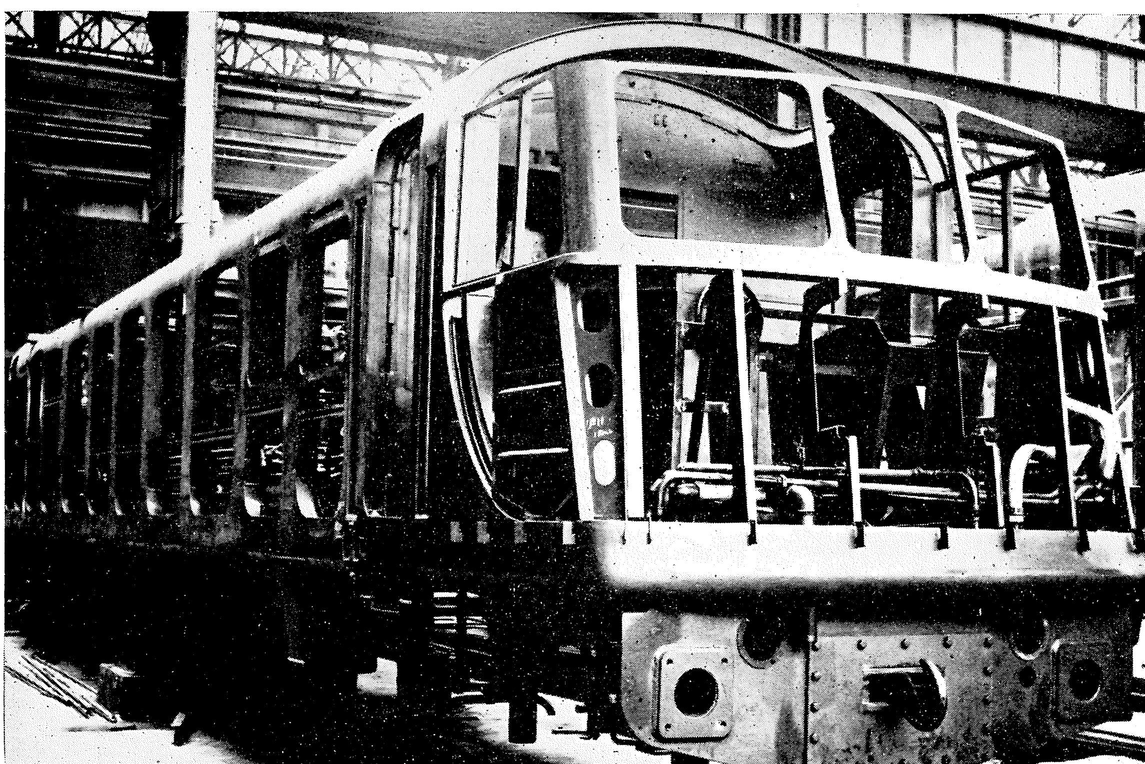


Fig.11 Locomotive superstructure. Nos.E.3036/45

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