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TECHNICAL DESCRIPTION OF BR CLASS 58 LOCOMOTIVES ....

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1. INTRODUCTION

All but 278 of the 2220 main line diesel locomotives operated by British Rail today were built between 1957 and 1965, which means that a large replacement bulge is looming.

It was in anticipation of this problem, and also to increase the efficiency and scope for merry-go-around coal movement to power stations following the 1973 oil crisis, that the current standard freight locomotive (Class 56) was designed. The first entered service in August 1976.

At the time of its inception, design resources were committed in other directions, so to avoid delay Class 56 was based on the prolific Class 47 design with a new engine rated at 3250 hp. It was built solely for freight haulage, with slow speed control for merry-go-round duty and no train heating. This is in line with current policy of building specialised passenger and freight motive power, rather than mixed-traffic locomotives.

In operational terms Class 56 has been very successful, indicating that the basic specification of 3250 hp, 60,000 lb maximum tractive effort, 80 mile/h top speed, 126 tons weight, and Co-Co wheel arrangement was correct.

But the 20 year old structural design, whilst technically sound, belongs to an age when skilled labour was relatively cheap and plentiful; in the 1980's construction of this locomotive is proving very expensive. Accommodation of the increased power equipment in the basic Class 47 bodyshell also led to restricted access for maintenance, and air distribution problems.

In 1977 British Rail Engineering Ltd requested BR's Locomotive Design office to prepare a report and design feasibility study on a low cost Co-Co locomotive of 2500 hp for export markets. The resulting design was based on a simple underframe made of rolled steel joists, with non-load bearing super structure, and costings show substantial savings compared with the monocoque class 56 built at Doncaster.

Class 58 is essentially an attempt to combine the lower costs and better maintenance access features of the export locomotive with the successfully proven basic specification and power equipment of Class 56.

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Objectives of the Class 58 design are:

(i) Economy in construction.

(ii) Ease of, and minimum overall maintenance costs.

(iii) Adaptation to export applications with minimum modifications, the opportunity being taken to incorporate some of the lessons that had been learned while commissioning Class 56.

2. LEADING PARTICULARS AND DIMENSIONS

BR Rating	2460 kW
Maximum Speed	130 km/h
Engine	Ruston RK3ACT 12 Cyl.
Traction Motor	Brush TM 73-62
Gauge	1435 mm
Wheel Arrangement	Co-Co
Length over buffers	19130 mm
Total wheelbase	14860 mm
Distance between bogie centres	10800 mm
Maximum height	3950 mm
Width over bodysides	2720 mm
Wheel diameter (new)	1120 mm
Weight (with full supplies)	130 tonnes
Maximum axle load	21.6 tonnes

3. STRUCTURE

For the first 35 locomotives, the structure is being supplied by BREL, Doncaster.

3.1 Body

The underframe is designed to carry all the static loads imposed by the equipment and those arising from dynamic forces when the locomotive is in operation. In addition, the underframe is designed to take an end load of 200 tons at buffer height and to allow lifting of the complete locomotive at the centre pivots without permanent deformation of the members.

The bodysides are of a "bonnet" type with access doors to equipment compartments and is based on modular design for ease and economy of maintenance.

A continuously welded sealing plate is provided to prevent waste spillage etc leaking through on to the bogies. A sump with a convenient

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drainage point is formed in the sealing plate beneath the diesel engine.

There are four removable roof sections giving access for removal of equipment.

3.2 Equipment Layout

The area between the driving cabs is divided into four sections.

The first section houses the radiator equipment, and one electrically driven traction motor blower. The radiator mountings, ducting, fan cowls and fan motor supports are incorporated in one complete removable module.

The second section houses the power unit, and compressors. Access to each side of the power unit is afforded by bodyside doors.

The third section houses the turbocharger air inlet and electrical equipment.

The fourth section houses the electrical control equipment cabinet, the main rectifier, the second electrically driven traction motor blower, and the brake equipment.

3.3 Cabs

Driving cabs are provided at both ends of the locomotive and are of fabricated modular construction, insulated against both heat and sound.

Particular attention has been paid to the general layout of the cab in terms of comfort and convenience for the operating crew. Front windows are divided by a centre pillar into two large area flat panes of high impact type glass with built-in electric heating elements for de-misting and de-frosting. Air operated single speed windscreen wipers are fitted at both windows together with high pressure windscreen washers and adjustable sun blinds. Sliding windows are positioned in the cab so that the driver and/or his assistant can lean out and see the rear of the train without discomfort. Robust doors fitted with fixed windows, and substantial slam locks give access from each side to the cross-walkway.

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Each cab has a single driving position arranged on the left hand side with an assistant's position on the right, each fitted with an upholstered adjustable seat. The main driving instruments, switches, warning lights and controls are mounted on a console type desk in front of the driver.

A door is provided in each cross-walkway giving access to the cab.

The floor is of plywood with a non-slip surface. Coat hooks are located in each cab and a boiling ring is provided in each cab.

Heating and force ventilation equipment is provided in each cab.

Two interior lamps are provided in each cab and instrument illumination is by edgelighting.

Two air horns, one with a high note and one with a low note are provided at each end of the locomotive. Each note is operated separately.

4. <u>BOGIES</u>

The bogies are supplied by BREL Crewe and are designated by BR "CP3". Each bogie is fitted with three driven axles.

The wheels are of monobloc type.

The main bogie frame is of welded construction consisting of two main longitudes of box construction incorporating substantial castings connected by cross-members which are castings/fabrications.

The bogie frame is supported from the axleboxes by the primary suspension consisting of helical springs in the vertical plane and "silentbloc" parallel rubber bushes in the lateral/longitudinal plane.

The outer axleboxes are each fitted with two roller bearings and the centre boxes are fitted with cylindrical roller bearings to allow lateral float.

Traction motors are axle-hung nose-suspended by means of links and rubber bushes. Safety brackets are provided.

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A bogie pivot pin is provided to guide bogie rotation and to transmit traction and braking forces from the bogie to the locomotive body. Rubber cushions are provided in the bogie frame to give resilience to the pivot pin.

Secondary suspension is by means of Flexicoils, there being 3 springs per side, fitted into pockets in the underframe of the locomotive.

Direct acting brakes are provided operated by one brake cylinder per two blocks and two cylinders per wheel. All cylinders are fitted with automatic slack adjusters.

Sanding is applied to the leading axle of each bogie for either direction of travel by air operated ejectors fed from bogie mounted sandboxes.

Control of the sanding operation is by means of electro-pneumatic valves actuated by a manually operated switch in each cab. The electrical connections to the magnet valves are by way of the main controllers such that the sanding is applied through the correct ejector group to suit the direction of travel.

5. <u>POWER EQUIPMENT</u>

5.1 <u>Engine</u>

The diesel engine, located centrally in the locomotive, is a Ruston RK3ACT charge air cooled 12-cylinder engine continuously rated at 2610 kW @ 1000 rpm having a BMEP at this rating of 16.9 bar although as fitted in the Class 58 it is de-rated to 2460 kW (15.9 bar BMEP).

It is of the four stroke turbo-charged type with a cylinder bore of 254 mm, a piston stroke of 305 mm with a mean piston speed of 10.2 m/s and arranged in two banks with an included angle of 45^{o}. The engine is of monobloc construction and is completely enclosed.

Lubricating oil and cooling water are circulated by pumps mounted on the engine and spur gear driven from the free end of the crankshaft.

A separate fuel injection pump is fitted for each cylinder and the fuel is injected mechanically into open type combustion chambers.

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The engine is controlled by a hydraulic servo type variable speed governor operating the fuel pump racks.

Speed control is operated by air pressure varied continuously by the locomotive controller and is linked with an electrically operated load control system which automatically relates the load on the alternator to the speed setting.

A power take-off is provided at the free end for driving the hydrostatic pump for the radiator cooling fan motors and air compressors.

The engine is designed for flange mounting of the main alternator. (See Section 5.2 Alternator).

The engine is started by twin d.c. motors designed to engage upon a geared ring attached to the engine flywheel and operation of the "start" button supplies power to the parallel and repeat start relays which automatically engage each starter motor pinion in turn (repeating until a successful engagement) and when both motors are in mesh the relays apply the battery power to the motors. After the initial run-up period and as the engine speed reaches 200 r/min an engine driven centrifugal switch, mounted on the free end of the engine, will break the circuit and cause the starter motor pinions to disengage and simultaneously stop the motor driven lubricating oil priming pump. As engine oil pressure increases the low oil pressure shut-down switch will maintain the supply to the fuel transfer pump motor and the engine-run-valve and gives an "engine running" lamp indication.

The engine cooling group consists of two single bank radiator panels which cool the engine jacket coolant and the coolant through the lubricating oil coolers and charge air coolers. The coolant is circulated through each system by engine driven, automatically lubricated centrifugal pumps.

Thermostatic control of fan speed is provided in both systems which permits rapid warming up of the coolant and maintains the operating temperatures within suitable working limits.

Engine air intake to the turbocharger situated at the alternator end of the engine, is by ducted air direct through cartridge type disposable filters located in the clean air compartment.

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5.2 Alternators

The alternators are specially designed for traction requirements, particular attention being paid to interchangeability, ease of maintenance, life of wearing parts and selection of insulating materials. High melting point solder is used throughout for all soldered connections.

The machines comply generally with the requirements laid down by the British Standard Specification No 173.

The set comprises a main and auxiliary alternator each having its own brushless exciter.

The main alternator rotor is built on a hollow hub which is solidly coupled to the engine crankshaft through a coupling adaptor. A solid flanged shaft extension which forms the auxiliary alternator rotor and carries both exciter rotors is bolted to the main alternator hub and is supported at its outer end by a roller bearing.

The stator assembly consists of two fabricated shells one carrying the main, and the other the auxiliary and exciter stators. The two shells are bolted together through an endframe integral with the auxiliary shell. The stator assembly is flange mounted to the engine over the bottom half through a spacing adaptor being held at the top by tie bolts.

The set is self ventilated, the fan being mounted on the coupling adaptor. Air is drawn in through the endframe and exciter shell and discharged through openings.

MAIN ALTERNATOR

The main alternator is a 3 phase, 12 pole, star connected machine the three phases and neutral being brought out to a terminal box.

Stator Assembly

The stator core is constructed of high permeability low-loss segmental stampings built up on dovetail keys which are bolted to pads in the stator frame. This allows cooling air to pass over the outside of the stator pack in addition to that through the vent holes. The stator pack is clamped between robust end-plates which have fingers to support the stator teeth. Diamond type high tension coils wound with cooper insulated with polyester enamel and silicon impregnated braided glass are used for the stator windings and are held in place by slot wedges.

Cont'd ....

Coil overhangs are securely braced to withstand short circuits.

Rotor Assembly

The rotor hub is a one piece alloy steel forging bolted and dowelled to the coupling adaptor.

Poles are secured to the rotor hub by high tensile steel studs, which are screwed into tapping bars in the pole laminations. Robust endplates clamp the pole assembly.

The coils are wound from braided glass insulated copper strip and are resin bonded to the pole bricks, adequate ground insulation being provided between the coil and pole.

AUXILIARY ALTERNATOR

The auxiliary alternator is a 3 phase, 8 pole, star connected machine, the three phases and neutral being brought out to a terminal box.

Stator Assembly

The stator is constructed from high permeability low-loss one piece stampings keyed to landings in a stator barrel which forms part of a fabricated shell containing the two exciters. The stator pack is clamped between robust endplates, thicker stampings being fitted at the core ends to support the stator teeth. Diamond type high tension coils wound with copper insulated with polyester enamel and silicone insulated braided glass are used for the stator windings which are held in place by slot wedges. Coil overhangs are securely braced to withstand short circuits.

Rotor Assembly

The shaft extension is a one piece alloy steel forging bolted to the main alternator hub.

Poles are secured to the shaft with high tensile steel bolts which seat on bars in the pole laminations.

Robust endplates clamp the pole assembly.

The coils are wound from braided glass insulated copper strip and are resin bonded to the pole bricks, adequate ground insulation being provided between the coil and pole.

Cont'd ......

EXCITERS

The two exciters have their stator cores pressed into barrels in a common shell with the auxiliary alternator. The armature cores are carried on landings of individual hubs and mounted on to a common sleeve which also carries the dual rotating rectifier assembly. The sleeve is fitted on to a tapered seating on the shaft extension and is removable by oil injection.

The stator and rotor laminations are formed into packs and retained by welding or riveting.

The stators and rotors are mush wound with polyester enamel covered copper wire and are retained by slot wedges.

5.3 Traction Motors

The Brush designed traction motors, designated TM 73-62 are a derivative of those used on the British Rail Class 45 locomotives and the Hawker Siddeley "Kestrel" locomotive, and Class 56 and particular attention has been paid to robustness combined with light weight, interchangeability, ease of maintenance, life of wearing parts and selection of insulating materials.

The motors comply generally with the requirements laid down by the BSS No 173.

The motor has 4 main poles, 4 compoles, 4 brush arms and is designed for axle and nose suspension. It is force ventilated from a duct system on the locomotive. This system is connected to the motor through a flexible ducting at the commutator end of the frame. The air then flows in parallel streams:-

1. Through ventilation ducts provided in the armature core and,
2. along the outside of the armature and through the space between field coils. It is finally ejected at the pinion end.

Axle Suspension

Traction motor axle suspension is by means of a Timken suspension tube fitted with a taper roller bearing at each end. Grease lubrication is employed and a grease nipple is provided.

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Gear Drive

The motor pinion drives a solid spur gear wheel mounted upon the axle. The gearwheel is machined from a steel forging with its teeth hardened by the induction hardening process after cutting.

The pinion, manufactured from an alloy steel forging, has a taper ground bore and is shrunk on to a similarly tapered armature shaft. The pinion is case hardened after tooth cutting and the teeth are subsequently ground to remove any distortion caused by heat treatment. In addition, the pinion teeth are relieved towards the motor side by grinding, to avoid undesirable load concentration.

Gearcase

The gears are enclosed in a robust case which is made in halves. The joint between the halves is shrounded to prevent the entry of dirt or moisture and the escape of lubricant. The case is bolted together at the ends and is supported on the motor by three brackets, one above and one below the axle, the third at its pinion end. Labyrinths are provided at all openings in the case to prevent the escape of lubricant or the entry of any undesirable matter.

5.4 Control

Power Circuit

The six traction motors are arranged in three series pairs, except in slow speed. Each pair is switched by an electropneumatic contactor.

There is one stage of field divert.

A single three-circuit electropneumatic reverser controls the direction of current flow through the motor fields.

A high-speed short-circuiter, operated under fault conditions, is connected across the output terminals of the rectifier, to divert fault current away from the traction motors and present a balanced 'fault' load to the rectifier.

The field winding is supplied from the electronic load regulator.

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The star-point of the main alternator is earthed via a choke and a rectifier bridge feeding the power earth fault relay.

Overcurrent relays are fitted around each of the alternator output cables, and are designed to operate should a main rectifier diode fail to the short-circuit condition. A pair of enclosed terminals is provided for power test purposes. The driver's ammeters are supplied from a ring-type current transformer around one of the alternator output cables.

Main Rectifier

There are six vertically-disposed aluminium heat sinks, each carrying four silicon diodes connected in parallel.

Across each set of four diodes is connected a hole storage capacitor.

The heat sinks are cooled by an air flow drawn through the rectifier from top to bottom by the alternator.

Slow Speed Control

The six traction motors are connected in series in slow speed, to better match the alternator characteristic. The engine speed is constant and at present is set at idling (450 rpm). The driver can select one of four speed settings, locomotive speed being sensed at two traction motors. The train speed is then automatically controlled, the driver simply controlling the brake if necessary (eg. downhill loading).

Wheelslip Correction

Electronic wheelslip detection is necessary due to the high tractive effort capability of this locomotive and the arduous duty encountered hauling heavy trains under the poor wheel/rail adhesion conditions known to prevail in Colliery and Power Station sidings.

The wheelslip detection system operates on the principle of comparing traction motor currents. When a wheelslip is detected the traction alternator excitation volts are rapidly removed, thus cutting the tractive effort. At the same time the load demand signal is driven down. When wheelslip has ceased the tractive effort is restored to a level lower than that pre-set before wheelslip, the reduction being proportional

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to the time for which wheelslip lasted. Thus severe or repeated wheelslip reduces the subsequent T.E. substantially thereby reducing the tendency to slip. When wheelslip ceases T.E. is gradually restored to its former level under control of the governor.

Fault Operation

In the event of a traction motor blower or pair of traction motors being isolated, the engine speed, and hence output power, is automatically restricted so that damage will not occur to equipment still in operation.

6. BRAKES

6.1 Air Brake (No vacuum braking equipment is fitted)

A modified E70 brake control system has been adopted for use on this locomotive since it offers the following advantages over conventional brake control by a pneumatic driver's brake valve at each driving position:-

1. Simpler pneumatic system

2. Simplifies design at the cab as large diameter pipes are not required to the driver's brake valve.

3. Adaptable for automatic control if required in the future.

The driver controls the Auto Air Brake by means of an electrical brake controller which energises any of three wires in a sequence corresponding to a predetermined brake demand. For an emergency application all control wires are de-energised. The brake pipe pressure control unit converts the controller brake demand (1 running and 7 braking steps) into auto air brake pipe pressure.

Standard features such as AWS, vigilance and overcharge are fitted.

Locomotives operated in multiple are controlled from the brake pipe pressure control unit on the occupied locomotive, the auto air brake pipe being connected by jumper hoses to each locomotive.

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6.2 Parking Brake

The parking brake fitted is applied and released hydraulically, the required pressure is generated by electrically driven pump. The parking brake operates on 2 wheels of one bogie and may be applied by using the parking brake push button in each cab.

7. PERFORMANCE

The Class 58 locomotive performance is shown in Figs 1 and 2 attached.

8. OPERATION

The design is such that up to three locomotives are operated in multiple with each other, but not with any other class of locomotive. At this stage it is not anticipated that train consists requiring 3 Class 58 locomotives will be introduced but the multipling feature is an operating convenience allowing the relatively easy movement of a number of locomotives by one crew.

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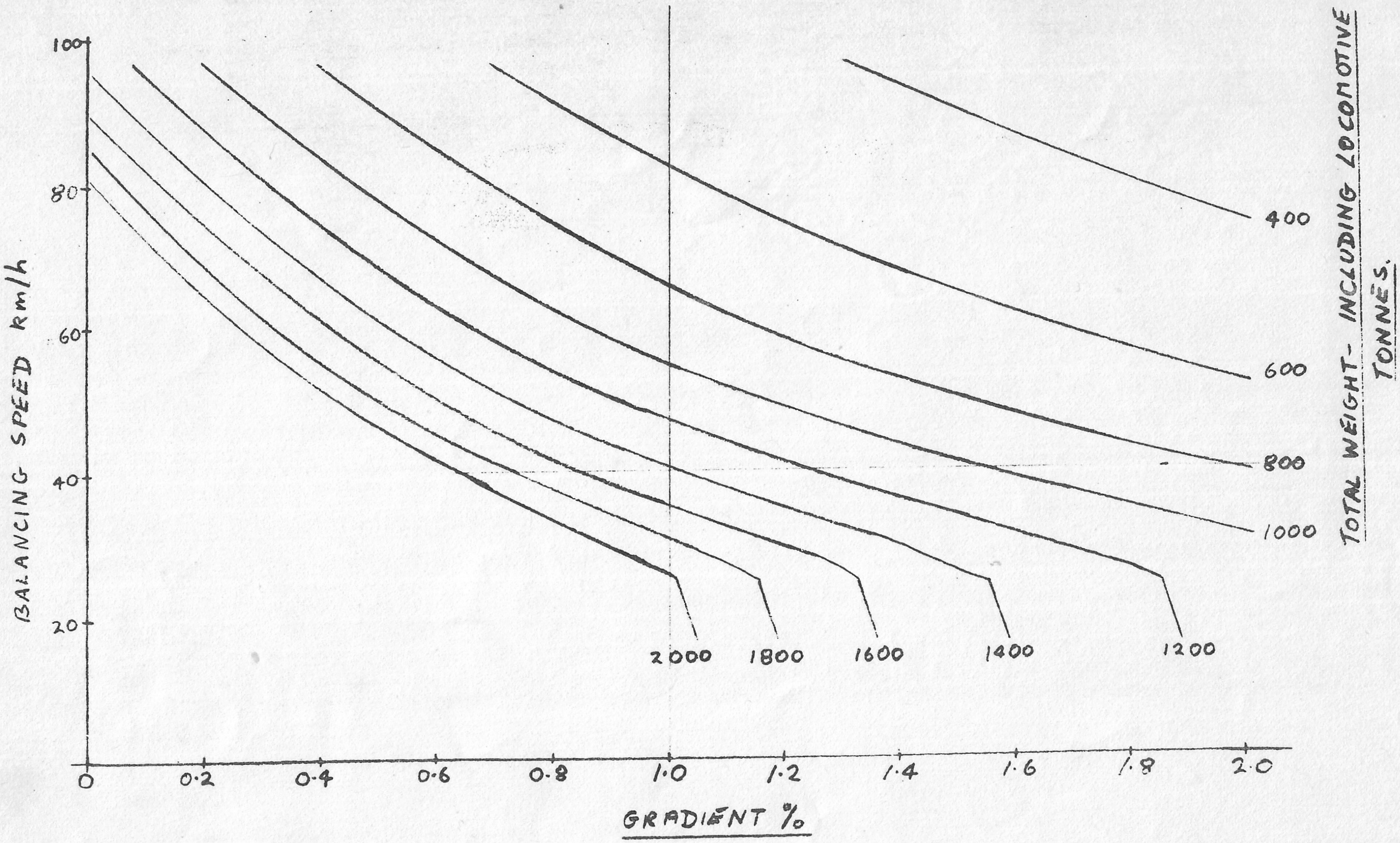
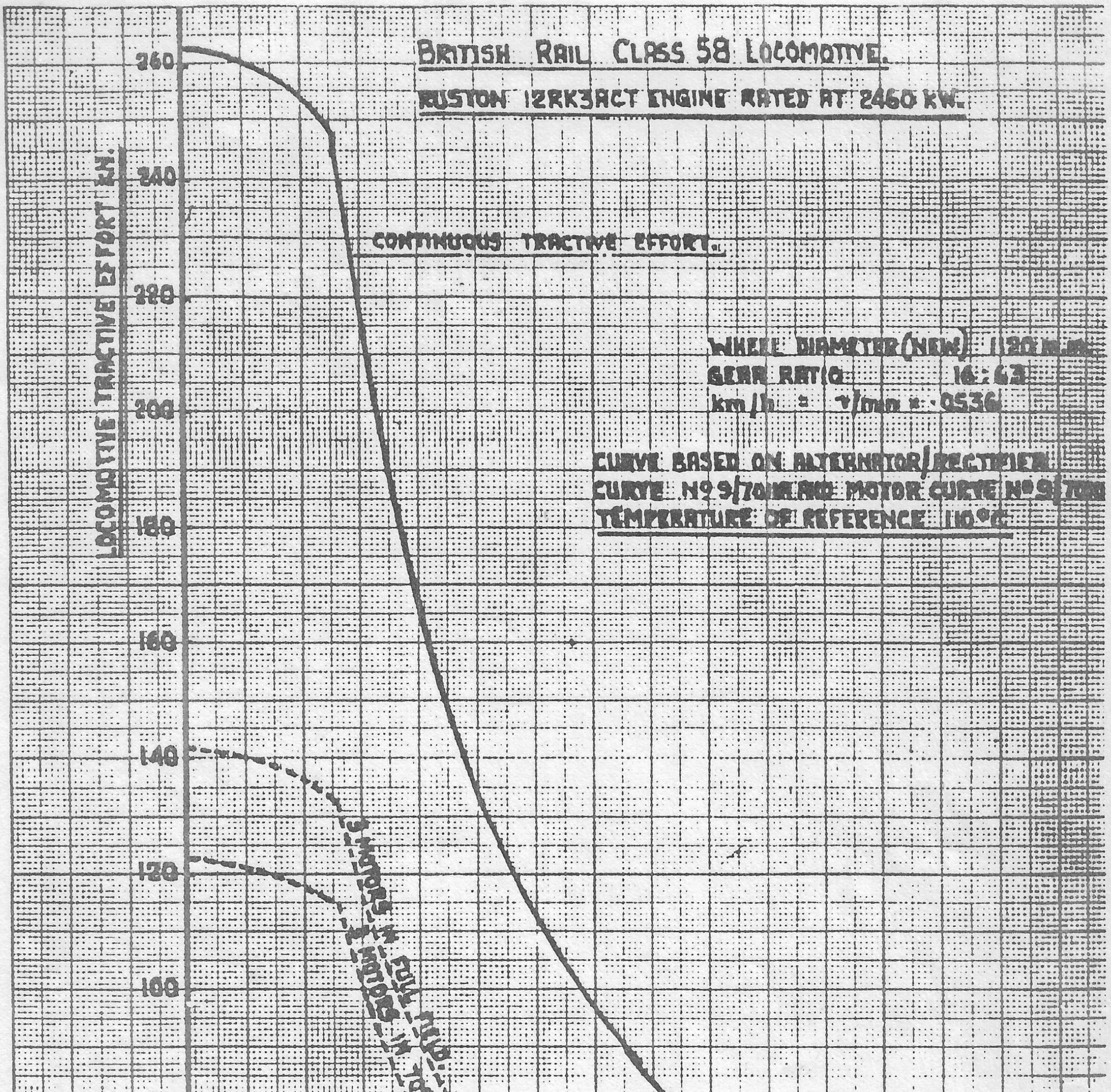


FIG 2 CLASS 58 PERFORMANCE DATA (ESTIMATED)



BRUSH ELECTRICAL MACHINES. LOUGHBOROUGH.

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