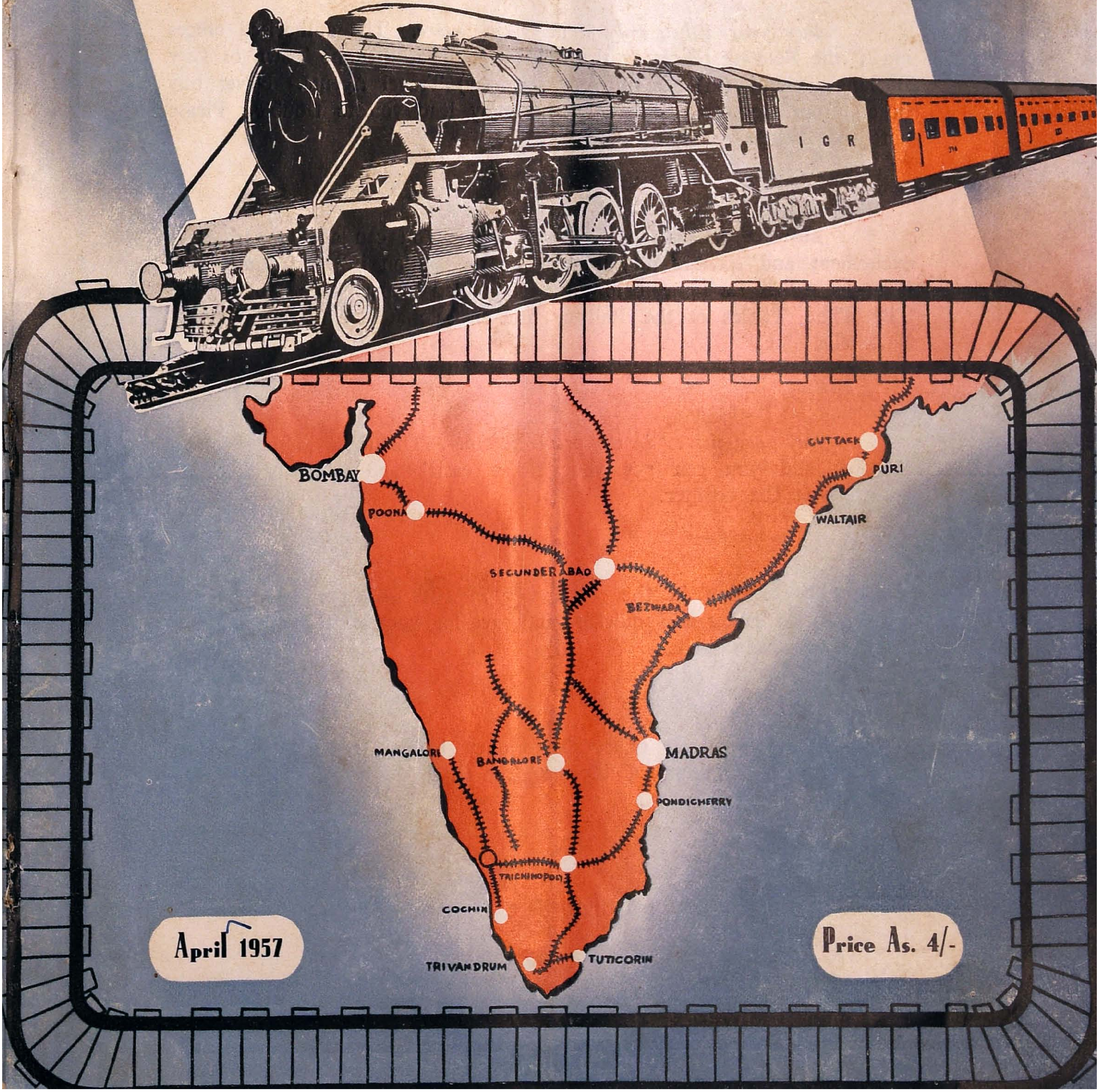
SOUTHERN RAILWAYS *Magazine*



April 1957

Price As. 4/-

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"A NEW DIESEL-ELECTRIC LOCOMOTIVE"

FUEL ECONOMY

THERE is usually a saving of 75% on the fuel cost of steam locomotive on shunting duties when replacing them by diesel-electric locomotives. This is due to the overall improvement in thermal efficiency and the elimination of lighting up and standby losses.

NO SMOKE OR DIRT

The exhaust of a diesel locomotive is clean and free from smoke, soot or ash. Elimination of smoke and other causes of air pollution is becoming a necessity. Driving of a diesel locomotive is a clean job.

AVAILABILITY OF HORSE-POWER

The nearly constant efficiency of electric transmission at about 80% over a wide range of rail speed with the diesel engine running at optimum speed provides the best utilisation of power and the diesel engine cannot under any circumstances be overloaded.

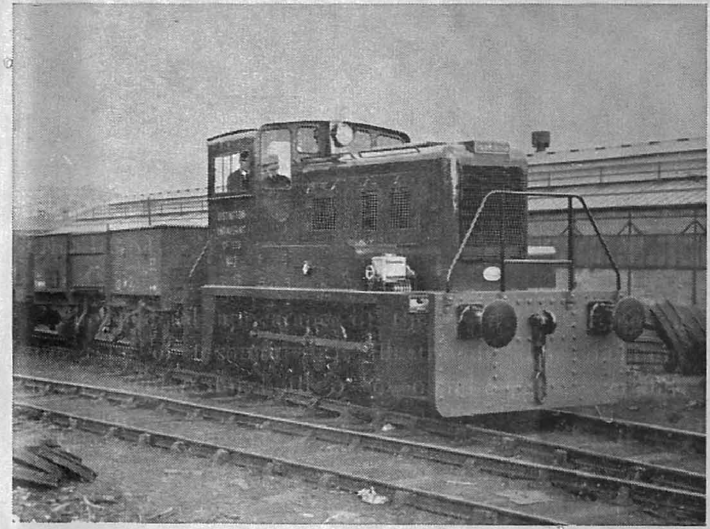
CONTROLS

The driving of a diesel-electric locomotive is a very simple matter. For example, it can be learned by a man in less time than it would normally take to learn to operate an electric crane.

There are no gears to change or clutches to operate. The controls can be grouped most conveniently to suit two driving positions.

AVAILABILITY AND MAINTENANCE

Experience has shown that a fleet of steam locomotives can be reduced by 20 to 30% by substituting diesel locomotives. This is because the short and long term availability of diesel locomotives is better. The time saved in coaling, watering and fire cleaning improves short term availability, and reduced time under repairs improves long term availability.



With electric transmission the locomotives need only a few hours at intervals of 200/300 hours for change of oil etc., a few days at 2500/3000 hours for top overhaul and no more than this at between 15000/20000 hours for complete overhaul of the engine and turning of tyres etc, if a spare engine/generator set is available and facilities exist for attending to wheels near at hand.

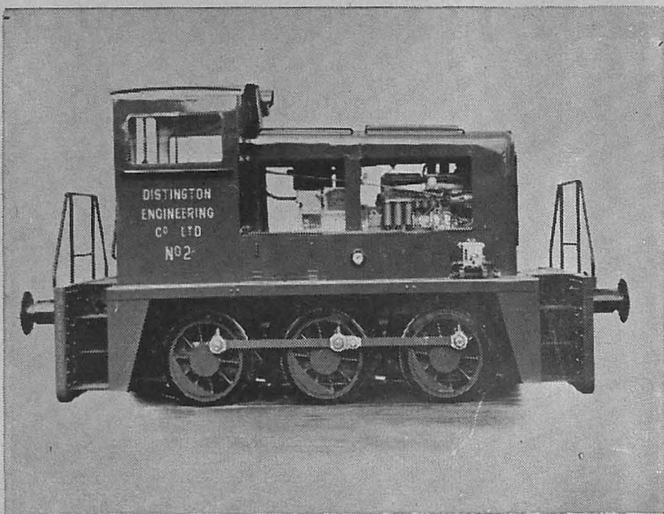
The power unit is resiliently mounted on the frame and there is no rigid connection of any sort between it and the wheels so that the engine is completely protected from shock. The traction motor is axlehung and free to float in any direction with a flexible nose suspension to absorb shock through the gears.

Electrical maintenance is very simple, particularly as the generator is motored for starting thus eliminating auxiliary electrical or compressed air starting equipment.

Yorkshire Engine Company and its sub-contractors responsible for the design and maintenance of the power equipment have a service organisation and carry spare parts.

GENERAL

The general appearance of the 0—6—0 version of this type of locomotive is illustrated. The diagrams and particulars for both 0—6—0 and 0—4—0 versions are given.



Both versions are identical so far as power equipment and weight are concerned, but for the 0—4—0 the overall length is reduced in proportion to the shorter wheel base.

The locomotives are of the rigid frame type with axles coupled together. The single traction motor is hung on the trailing axle and drives this axle through a gear box containing a right angle spiral bevel and single spur reduction totalling 22.85 : 1.

FRAMING

As the engine generator set is compact and independent of the undergear most of the weight is used to provide a rigid frame built up of rolled steel plates to B. S. 24, part 6, spec. 17, placed inside the wheels with fabricated stretchers all bolted together. Massive buffer beams are employed with good support and these are brought down to $5\frac{1}{4}''$ from rail level in order to cover the gear box in case of derailment. The whole structure is designed to withstand heavy traction and buffing shocks and has the necessary weight to provide the adhesion required for the high starting tractive effort and brake power available.

The axle box guides are steel castings of heavy proportions fitting closely into the frames and secured with driving fit bolts.

GENERAL PARTICULARS

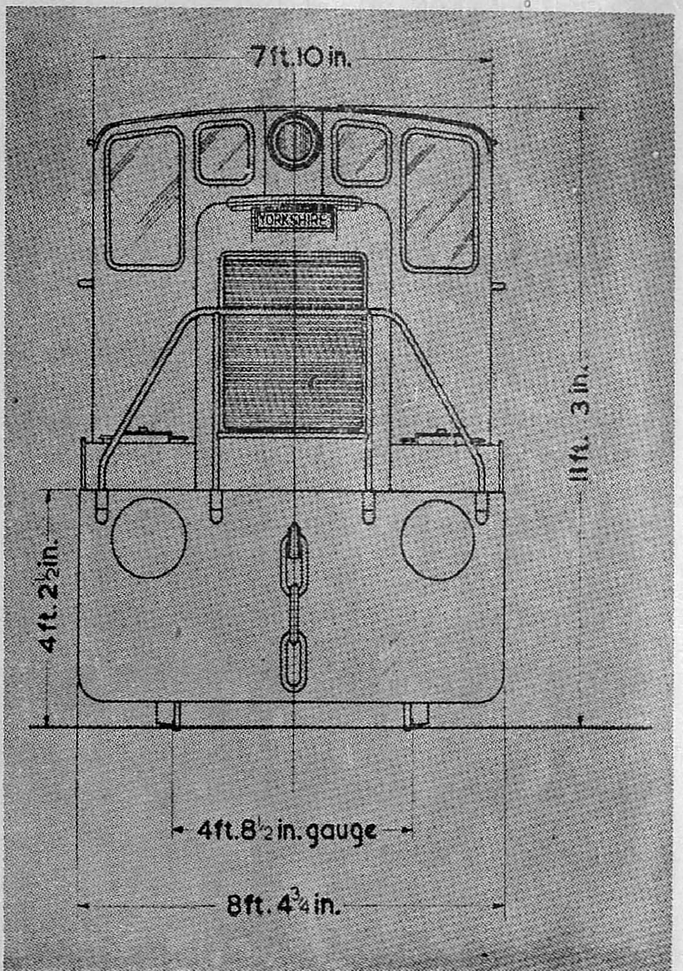
Locomotive weight	30 tons
Locomotive maximum tractive effort	18,000 lb.
Tractive effort at continuous rating	7,400 lb.
Speed at continuous rating	7 m. p. h.
Maximum permissible speed	20 m. p. h.
Oil Engine Supercharged	Rolls Royce C. 6. SFL
Total installed diesel engine rating at 1,800 r. p. m.	200 h. p.*
Horsepower available for traction at 1,800 r. p. m.	185 h. p.*
Generator	B. T. H. Type RTB. 6032
Traction motor	B. T. H. Type RTA. 5041
Gear ratio	22.85 : 1
Minimum rail clearance	$5\frac{1}{4}''$
Radiator	Rolls Royce
Battery	D. P. Lead acid 24 cells. 24/48 volts. 77 amp./hrs. at 5 hour rate of discharge.
Track gauge	$4' 8\frac{1}{2}''$, $5' 3''$ or $5' 6''$
Length over buffer beams 0—6—0 version	$19' 4\frac{1}{2}''$
Length over buffer beams 0—4—0 version	$18' 2\frac{1}{2}''$
Length overall (1′ 6″ buffers) 0—6—0 version	$22' 4\frac{1}{2}''$
Length overall (1′ 6″ buffers) 0—4—0 version	$21' 2\frac{1}{2}''$
Width overall, standard gauge	$8' 4\frac{3}{4}''$†
Width over cab, standard gauge	7′ 10″†
Height over cab, standard gauge	11′ 3″†
Number of driving positions	Two
Wheel arrangement	Six or Four
Wheel base 0—6—0 version	9′ 0″
Wheel base 0—4—0 version	6′ 0″
Wheel Diameter	3′ 3″
Can negotiate curves 0—6—0 version	100 ft. radius
Can negotiate curves 0—4—0 version	60 ft. radius
Type of buffers	Optional
Type of couplers	Optional
Type of axlebox	Plain leaded phosphor bronze or roller bearings.
Brake Equipment	Westinghouse straight air brake. Rolls Royce compressor mounted on engine and belt driven. 15 cu. ft. per min. swept volume.
Fuel tank capacity	200 galls.

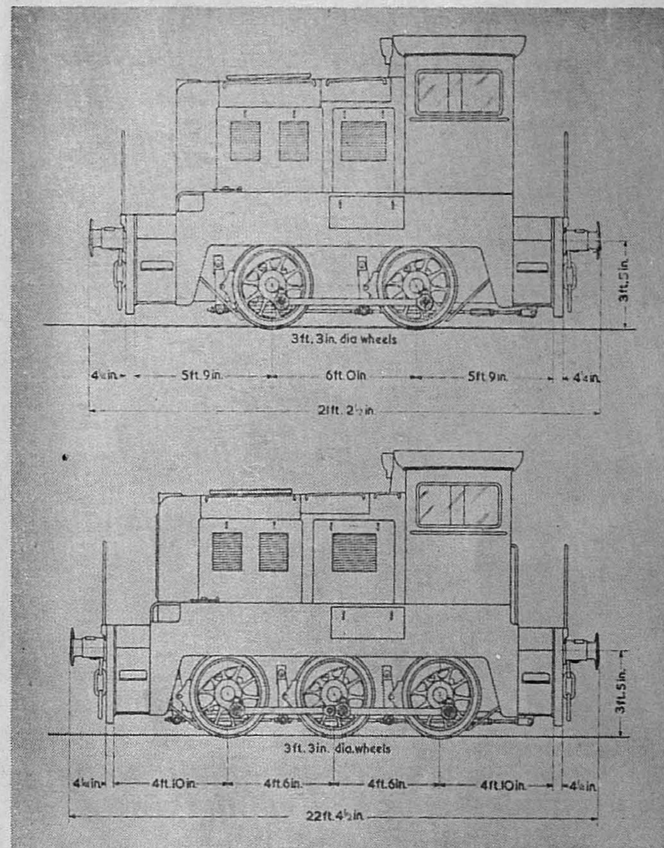
Notes:

* Rating would be reduced for altitude and temperature.

† Width and height of cab and fuel capacity can be reduced or increased to suit loading gauge.

The decking, which is combined with the platforms form a continuous cover over the frames and eliminates any possibility of oil or water from the power unit above seeping through on to the traction motor. The decking is provided with bearer plates on





which the three point supports of the power unit are carried.

The stretchers are positioned to give the maximum support to the power unit and for the nose suspension of the traction motor. There is a strong brace between the frames below the motor provided with a heavy pin linkage so that it can be readily removed when dropping this pair of wheels.

AXLEBOXES

Steel cast axleboxes to B. S. 24, part 4, spec. 10 are fitted as standard. These are provided with renewable leaded phosphor bronze bearings and collar liners. Manganese steel side liners are also provided. The axleboxes are fitted with cast iron keeps containing Armstrong oiler pads. The axlebox bearings are lubricated from a mechanical lubricator mounted on the platform and driven from the leading wheel axle. Alternatively roller bearing axleboxes with manganese side liners can be fitted. These are grease lubricated and therefore the mechanical lubrication is not fitted.

SPRING SUSPENSION

Laminated bearing springs with adjustable sword type hangers rest on the axleboxes and can be readily changed if necessary from underneath. The springs are manufactured from acid or basic water hardening spring steel in accordance with B. S. 24, part 3, spec. 6X.

WHEELS AND AXLES

Cast steel wheel centres to B. S. 24, part 4, spec. 10 are keyed and pressed on to solid forged axles to B. S. 24, part 1, spec. 2, and fitted with forged pins to B. S. 24, part 4, spec. 9, pressed into the wheel centres. The revolving masses are fully balanced in the design of the wheel centres.

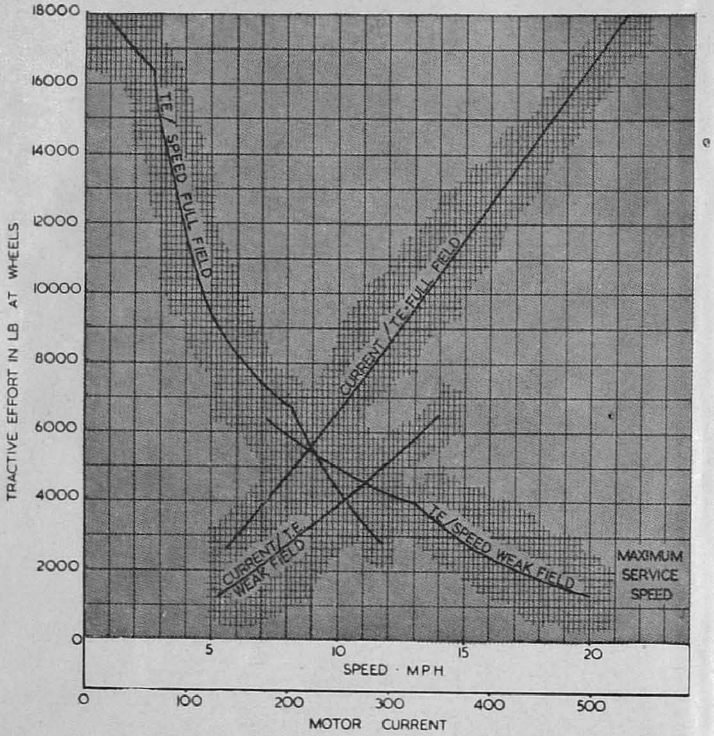
TYRES

Tyres of steel to B.S. 24, part 2, spec. 4, for class 'D' are shrunk on to the wheel centres.

COUPLING RODS

The wheels are connected by coupling rods forged and machined from acid steel class 'C' and in accordance

PERFORMANCE OF 200 H.P. DIESEL-ELECTRIC LOCOMOTIVE



TRACTIVE EFFORT—SPEED CURVE

with B.S. 14, part 4, spec. 8, and are provided with solid leaded phosphor bronze bushes.

POWER BRAKES

The locomotive is equipped with Westinghouse straight air brakes. Provision is made for adjustment. The brake pressure at the cylinders is 50 lbs. per square inch. The compressor, as standard to the Rolls Royce C6S diesel engine having a capacity of 15 cu. ft. swept volume of air per minute, is driven by Fenner vee belts from the engine. The air reservoirs have a capacity of 10 cu. ft. The unloader and safety valve are mounted adjacent to the reservoirs. The feed valve, driver's valve and Duplex gauge are mounted in the cab and the brake can be applied from both sides.

DRAWGEAR

Turplat forged side buffers and Gedges hooks and three link chains are fitted as standard. Any special buffer and drawgear can be fitted if required.

CAB

The driver's cab is constructed of steel plates welded together to form a totally enclosed structure provided with a door at the back. The windows in the front and back panels are fixed with rubber sealing strip, but the side windows and the windows in the side doors are fitted with sliding and drop windows. The control desk, containing contactors and other switch gear and on which are mounted the control levers and instrument panel, is located against the front bulkhead. The control levers, consisting of the throttle, reverser, brake, sanding and whistle levers are duplicated on either side within easy reach of the driver. The throttle and reverser are mechanically interlocked to prevent the reverser being thrown when the throttle is open, or the throttle opened when the reverser is not in either the forward or back position. The instrument panel is provided with 'Start' and 'Stop' buttons, fuel pressure, engine R. P. M., oil pressure, water temperature, battery charge ammeter, speedometer and air brake Duplex gauges. A separate panel on the bulkhead has switches for the head and tail lights, cab light and heater switches and a pilot switch. An earth leakage relay is mounted on the bulkhead. On the control cabinet is also provided the battery changeover switch. In the 'Start' position, the 24 cell battery is in series, to give 48 volts to motor the generator, and in the 'Run' position the batteries are in parallel to give 24 volts for lighting and heating. The hand brake is located on the rear bulkhead. A Servis recorder is included as standard, and also mounted on the bulkhead. The floor is covered by wooden boards. The height and width of the cab can be modified to some extent to suit running dimensions, or for customers' special requirements. A toolbox is provided combined with the desk on the left side. A platform is provided behind the cab, approached by step-ins on either side. Windscreen wipers are supplied.

BATTERY

The 24 cell battery is contained in two battery boxes mounted on the platforms.

POWER UNIT

The power unit comprises the Rolls Royce C6-SFL supercharged oil engine direct coupled to the single bearing generator which is spigot mounted to the engine frame. The radiator is connected to the front of the engine and the whole unit carried on three point resilient suspension mounted on the engine deck. The radiator, auxiliary generator and compressor are driven from the free end of the engine with Fenner vee belts. The complete power unit and control equipment are supplied by The B. T. H. Co. Ltd., Rugby and a detailed description of this equipment follows.

BONNET

The bonnet enclosing the power unit is built up of two sections which are easily detachable for maintenance purposes. The forward portion includes the front moulding on which is mounted the radiator grill and encloses the diesel engine and its auxiliaries, while the rear portion encloses the generator and switch gear mounted on the front of the cab bulkhead. The engine air filters and exhaust silencer are mounted on the roof of the rear portion as it is only necessary to remove the front portion to attend to any major repair on the engine or its auxiliaries. As the weight of the locomotive required is provided mainly in the form of a strong frame, the bonnet sections have been fabricated mainly by welding from the lightest steel mouldings, and consistent with the necessary strength. Doors and covers are arranged for access to the power unit and these are provided with louvres with such air space as is necessary to provide for ventilation. The exhaust pipe and front head light are combined in a neat moulding on the front of the cab above the bonnet.

LIGHTING

The locomotive is provided with forward and rear headlights and a cab roof light.

CAB HEATING AND VENTILATION

A Clayton Dewandre heater with ventilating fan of the latest type is provided in the cab.

MATERIALS

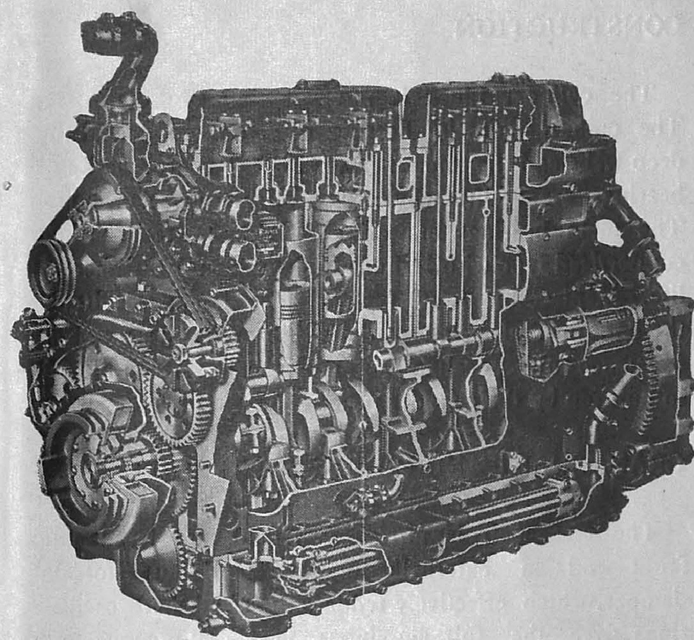
All materials, bolts, rivets and nuts are to British Standard Specification.

PAINTING

The locomotive will be painted to suit the customer's requirements.

TESTING AND TRIAL RUN

If required arrangements can be made for customers or their Consulting Engineers to examine the drawings or materials and visit the works to see the locomotives under construction. The power equipment is tested at the maker's works and the locomotive undergoes extensive trials before delivery. An acceptance test before the customer's representative can always be arranged.



Internal construction of the 6-cylinder dry sump engine.

TRAINING CUSTOMER'S STAFF

It can be arranged for customer's fitters and drivers to attend courses of instruction during the final stages of construction of their first locomotive.

AFTER SALES SERVICE

A Service Engineer will accompany the locomotive to the customer's works and remain with it for five days. The manufacturers of the mechanical parts, electrical machines and diesel engine will make periodic visits to the customer's plant during the maintenance period to ensure that the operation and maintenance is fully understood and to assist in any way to ensure satisfactory results.

SPECIFICATION

Type	4 stroke, direct injection, liquid cooled
Bore	$5\frac{1}{8}''$ (130.175 mm.)
Stroke	6″ (152.4 mm.)
Capacity (swept volume)	742.64 cu. in. (12.17 litres)
Compression ratio	14 : 1
B. H. P.	200 at 1,800 r. p. m.
Rotation	Anti-clockwise viewed on flywheel
Fuel system	Direct injection governed at all speeds.
Lubrication system	Dry sump with heat exchanger. Full flow filters.

CONSTRUCTION

The cylinder block is integral with the crankcase. The crankshaft main bearing caps are supported by deep webs and the more heavily loaded centre and end bearings are additionally secured by transverse bolts. The main bearings are of pre-finished steel backed copper/lead type with Indium flash to ensure satisfactory life. Replaceable 'wet' type cylinder liners are fitted; the bottom seal being made effective by heat and oil resistance rubber sealing rings and the liners are nipped in position by the cylinder head.

CRANKSHAFT AND CONNECTING RODS

The crankshaft is nitride hardened and has at the front end an externally mounted viscous torsion damper, which effectively reduces the crankshaft oscillations over the full running range. The connecting rods are drilled longitudinally for pressure lubrication of the gudgeon pins, and for splash to the cylinder walls.

PISTONS AND VALVES

Each of the light alloy pistons is fitted with three compression rings and one oil scraper ring and is recessed in the crown to form a toroidal combustion chamber. The overhead valves are push rod operated and both inlet and exhaust valves have stellited seat faces and stem tips to minimize wear.

SUPERCHARGER

The supercharger is of the Roots positive displacement type, mounted on the crankcase and driven by a gear train and spring drive from the timing gears at approximately twice crankshaft speed; this gives about 8 lb. per sq. in. boost at an engine speed of 1,800 r. p. m. Pressure lubrication is provided from the main engine lubrication system.

AIR CLEANERS

Multiple air cleaner units have been developed for this engine by Rolls Royce Ltd. to ensure the highest practicable degree of air filtration. These comprise centrifuge primary and heavy duty oil bath secondary filters.

OIL HEAT EXCHANGER

To bring the engine oil rapidly to its most efficient working temperature and to maintain it at that temperature under all conditions, a heat exchanger is used. Maintenance of correct engine temperature, apart from increasing the efficiency shortens the warming up period and so reduces wear.

On starting the engine the coolant radiator is by-passed, the warming coolant then re-circulating through the heat exchanger chamber and engine. When the coolant reaches 73 °C. the automatic thermostat control opens and allows the coolant to circulate through the radiator.

LUBRICATION SYSTEM

A dry sump is fitted which reduces the overall height of the power unit and ensures efficient lubrication of the engine on any railway gradient. This sump incorporates an oil to water heat exchanger together with an oil reservoir. Two scavenge pumps return the oil to the reservoir and a pressure pump supplies the main feed to the engine.

Oil is pumped through the heat exchanger and full flow filters to the main feed gallery for distribution to the crankshaft main bearings, crankpins and gudgeon pins, and through drillings in the crankcase to the camshaft bearings and the bearings of the wheelcase gears. Smaller drillings feed oil to the valve rocker shaft bearings, the push rod ball ends and the end of the valve stems at a lower pressure. Twin oil relief valves are fitted; one valve maintains the main oil pressure at 40 to 60 lbs. per sq. in. and the other provides a by-pass in the event of the oil filters becoming choked.

COOLING SYSTEM

The coolant is circulated by a belt driven centrifugal pump through the oil heat exchanger, engine and radiator. Provision is made for fitting a cooling fan, and a thermostatically operated valve causes the coolant to by-pass the radiator until it reaches a predetermined temperature.

Whilst water can be used as a coolant, a correctly inhibited anti-freeze mixture is recommended for use all the year round, as this not only provides protection against frost but prevents corrosion within the cooling system.

FUEL SYSTEM

A fuel injection pump mounted on the side of the engine supplies fuel to the injection nozzles on the cylinder heads. The injection pump is driven from the engine wheelcase, and includes a lift pump for supplying fuel from the main tank to the injection pump through paper element filters. The injectors are easily accessible for servicing. A mechanical compensated speed control governor forms part of the injection pump unit and ensures close governing at all speeds within the running range.

ELECTRICAL UNITS

A Simms dynamo of 960 watts output, is mounted on the crankcase and is belt driven in series with the coolant pump. The belt tension is adjusted by moving the dynamo. This dynamo provides the charging current for the twin lead-acid battery which is in two sections rated at 77 A. H. at the five hour rate of discharge.

The engine is not fitted with a normal type of axial starter as starting in this installation is through the generator and operates on a forty-eight volt circuit requiring a series parallel battery switch described later.

ENGINE SERVICE COUNTER

An engine service counter is fitted to provide an accurate means of determining the correct time for servicing.

MAIN DRIVE

The engine is designed for coupling direct to a single bearing generator. The engine-generator set is able to run indefinitely at any speed within the running range without incident of critical speed of torsional vibration. A viscous type vibration damper is attached to the free end of the crankshaft.

FUEL OIL RECOMMENDATIONS

It is recommended that Rolls Royce engines should be operated on fuel oils conforming to B. S. S. No. 209 (1947) Class A, but engines can also be operated on fuel conforming to B. S. S. 209 (1947) Class B. The makers will be pleased to give their recommendations for any fuel that does not meet the Class A specification and they should be consulted in every case.

CONTINUOUS RATING—(Self Ventilated)

kW	*Volts*	*Amps.*	*R. P. M.*
124	500	248	1800
113	378	300	1660

Ratings in accordance with BS. 173/1941.

WEIGHT

Approximately 2,200 lb.

CONSTRUCTION

This machine is a single bearing, 6 pole, commutating pole traction generator specially designed for direct coupling to a diesel engine.

FRAME

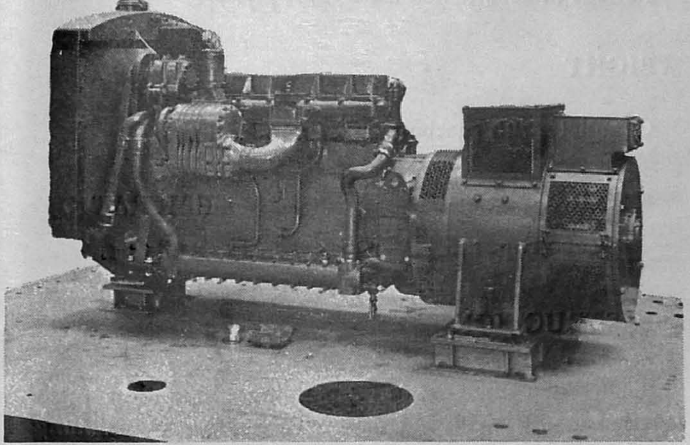
The magnet frame is of the fabricated, barrel type with adequate opening for ventilation and access to the commutator and brush gear.

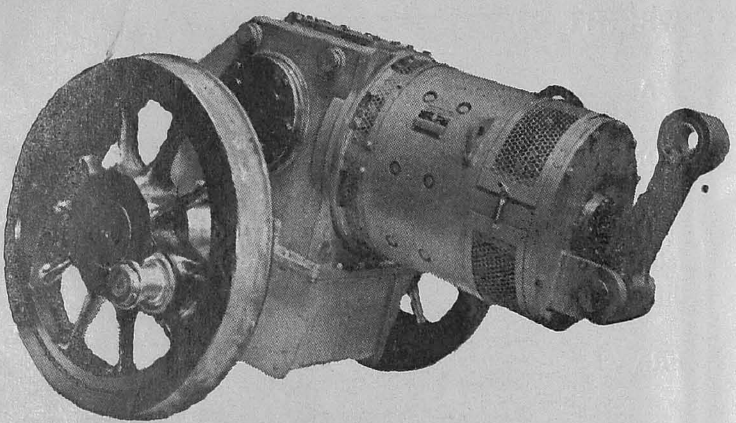
ARMATURE

The armature punchings are of thin electrical sheet steel and are secured on arms welded to a cylindrical spider by means of a heavy interference fit obtained by shrinking. A flexible coupling on the end of the spider is bolted direct to the engine flywheel. The armature windings are held in place by wedges of bonded material which retains its mechanical strength at high temperatures. Mica, glass and asbestos are used exclusively for coil insulation and all connections are brazed. The commutator is of the conventional Vee clamp ring design with hard drawn copper segments insulated with mica.

FIELD COILS

Self and separately excited field coils are provided. These are wound on the same former and are "Mummified." The compole coils consist of edge wound strip copper. A starting winding consisting of strip copper is also fitted on each main pole.





Mica, glass and asbestos are used exclusively for all coil insulation.

BRUSH HOLDERS

The brush holders are mounted on arms attached to a fabricated brush yoke and are adjustable radially. Split brushes are used with equalized pressure on each brush.

BEARINGS

The single bearing at the commutator end is a single row ball type arranged for grease lubrication.

VENTILATION

The fan is of fabricated steel construction and provides adequate ventilation of armature and field coils.

CONTINUOUS RATING ON FULL FIELD
(Self Ventilated)

SHP	*Volts*	*Amps.*	*R. P. M.*
143	440	270	1330

Ratings in accordance with BS. 173/1941.

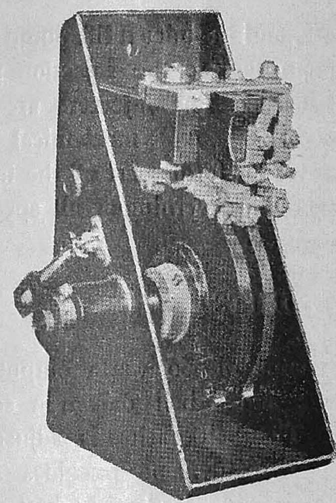
WEIGHT

Complete with gearbox, approx. 3,800 lb.

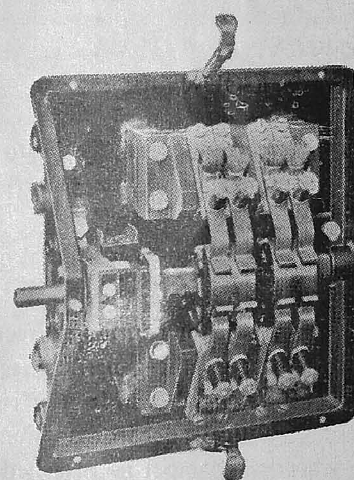
MAXIMUM SPEED	GEAR RATIO
4000 r. p. m.	22.85 : 1.

CONSTRUCTION

This machine is a 4-pole commutating pole traction motor which is spigot mounted on an axlehung gearbox.



Power Controller.



REVERSER

FRAME

The magnet frame is of the fabricated, barrel type with adequate openings for ventilation and access to the commutator and brushgear.

ARMATURE

The armature punchings are mounted directly on a very substantial shaft and are hot stacked under pressure. The windings, consisting of rectangular copper conductors, are insulated entirely with glass and mica and all connections are brazed. The armature windings are held in place by wedges of bonded material which retains its mechanical strength at high temperatures. The commutator is of the "Pollock" type in which the segments are retained against centrifugal force along their entire length. The spiral bevel pinion has a taper shank which is a very heavy press fit in a corresponding taper bore in the armature shaft.

FIELD COILS

These consist of edgewise wound strip copper insulated with asbestos and mica.

BRUSH HOLDERS

The brush holders are mounted on arms attached to a fabricated brush yoke and are adjustable radially. The brushes are split and are fitted with stranded copper shunts.

BEARINGS

The armature is carried on anti-friction bearings. A plain roller bearing is used at the commutator end. A pair of bearings is used to take the thrust and journal loads at the pinion end.

VENTILATION

A cast aluminium radial type fan provides adequate ventilation of armature and field coils.

GEARBOX

The gearbox is of fabricated steel construction and is split on the axis of the road axle. The lay shaft, which carries a spiral bevel wheel and spur pinion, is mounted on anti-friction bearings, cartridge mounted. The gears can be thrown out of mesh by external adjustment of the cartridges soas to allow the locomotive to be towed safely at speeds above the normal maximum.

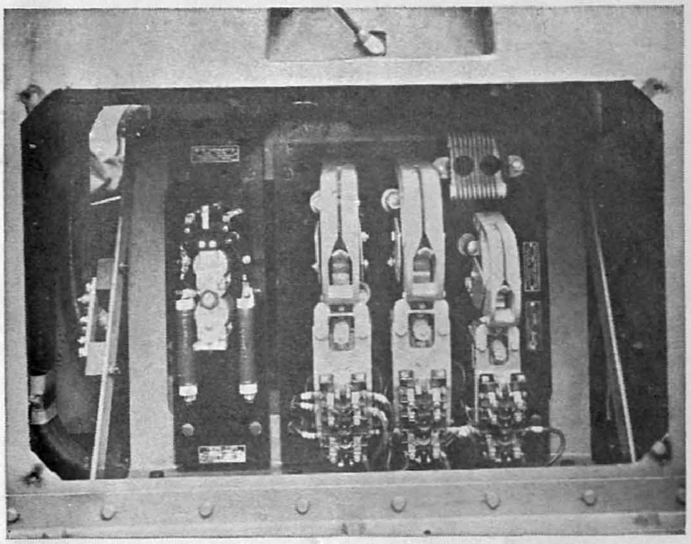
The gearbox is carried on the road axle in split type oil-lubricated sleeve bearings.

GENERAL DESCRIPTION

The control equipment consists of a power controller, reverser, contactor panel and battery series-parallel switch.

POWER CONTROLLER

This is a cam operated unit with two silver tipped contacts through which the two contactors supplying power to the motors are energised. The lever of this power controller is mechanically linked to the governor and is used to control the engine speed. Mechanical interlocking is provided to ensure that this controller can be operated only when the reverse lever is fully in either the forward or reverse position.



Contactor Panel.

REVERSER

One standard single motor reverser is operated mechanically by the reverser lever. It has four pairs of copper contact fingers which engage with segments on the drum. Electrical interlocks ensure that the motor contactor can close only when the reverser is fully in either the forward or reverse position.

CONTACTORS

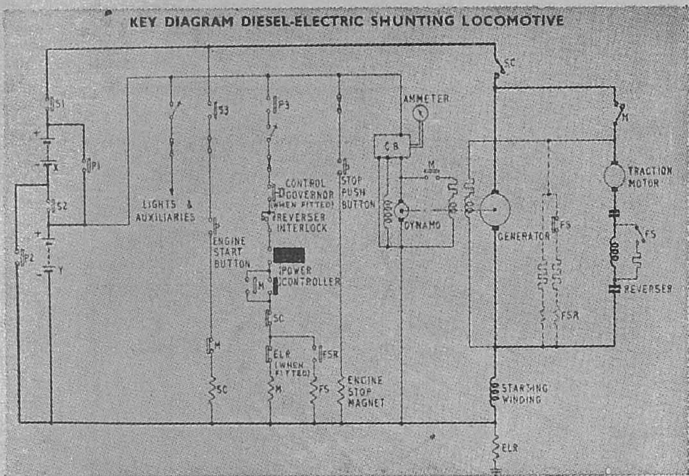
One contactor is in the main motor circuit and one provides a divert resistance to give field shunt above a predetermined speed. The third contactor is in the generator circuit for engine starting purposes. These contactors are electrically interlocked to prevent the motor contactors and the starting contactor being closed at the same time. They are single pole, magnetically operated and are of simple and robust design. The construction includes a straight armature with rocker bearings. Blowout coils and arc chutes are provided to assist in rupturing the arc.

FIELD SHUNTING EQUIPMENT

Field shunting equipment consists of a field shunting contactor, resistor and a relay. The relay is connected across the generator and operates to introduce the field shunting of the traction motor automatically when conditions are suitable.

EARTH LEAKAGE RELAY

A hand reset, indicating earth leakage relay is provided in the driver's cab.



M = Motor contactor.
SC = Starting contactor.
FS = Field shunt contactor
FSR = Field shunt relay.
ELR = Earth leakage relay.
CB = 24 volt. voltage regulator.
P1, 2 & 3 = Battery series parallel switch–parallel contacts.
S1, 2 & 3 = Battery series parallel switch–series contacts.

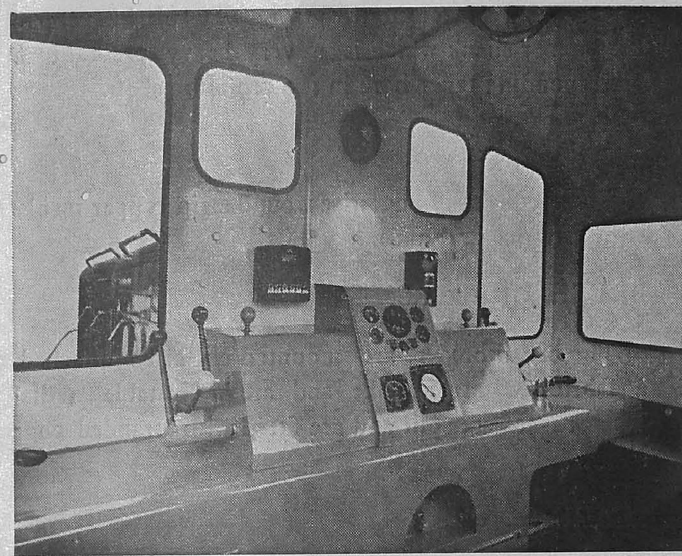
SYSTEM OF CONTROL

The fundamental traction circuit consists of a reverser and a contactor to connect the traction motor to the generator The contactor is operated from a 24 volt battery and the reverser is mechanically operated by a link from the driver's reverse lever.

The traction contactor is closed by the throttle switch which is linked, together with the governor speed lever, to the driver's power controller. The locomotive power is varied by variation of the engine speed so that, once the traction contactor has closed, no further change takes place, and the movement of the controller lever serves only to increase the speed of the diesel engine by altering the setting of the governor. Traction motor field shunting takes place automatically at a predetermined generator voltage.

The control system is based on a self-excited shunt wound generator coupled to the diesel engine. When using a diesel engine for traction duty it is essential to introduce some means of employing the full engine horse power over a wide range, if the tractive effort of the locomotive is to be prevented from falling off rapidly at higher speeds. The scheme adopted by BTH on this locomotive is designed to give the widest possible use of engine horse power with the simplest of equipment.

The series wound motor is connected by a contactor through a reverser to the main generator which is designed with a steeply drooping characteristic. A light



Control desk.

separate shunt field is provided to give a fixed short circuit current. This short circuit current is chosen to correspond to a suitable "stall" tractive effort of the motor and thus is self-protecting.

The generator also has a series winding which is provided in order that the engine may be started by motoring the main generator from the supply available from the battery.

The characteristic of the machine is also very sensitive with speed, and advantage is taken of this to prevent overloading of the diesel engine in the manner now described.

The maximum output of the diesel engine is determined by a fixed stop on the fuel injection pump control rack. As the generator increases its loading upon the engine, fuel is increased by the governor until this maximum is reached, after which further loading on the engine will cause a reduction in engine speed. This reduction in speed, however, rapidly reduces the generator voltage and hence its loading upon the engine until a balance point is reached. The reduction in speed is never sufficient to cause serious loss of available engine power.

This system of control provides continuous and entirely smooth variation of locomotive speed and tractive effort between standstill and full horsepower simply by varying the engine speed.

For further information apply to the United Steel Companies (India) Private Ltd., P. B. 673, Bombay. P. B. 119, Calcutta.

RIDING QUALITIES OF RAILWAY COACH

By A. C. Bhattacharya, A.M.I.P.E.

THE trend to higher standards of ride quality of Railway Rolling Stock is as gradual as it is inevitable. The Railway Engineers throughout the world are realising that amongst the amenities which are being provided for the passengers, the best riding condition is one of paramount importance. Its value lies not only in increased passenger comfort and reduced damage to freight but also in reduced maintenance costs resulting from diminished vertical and horizontal movements.

In India, where long journeys are performed by rail, the need for good riding Coaches is still greater. Apart from comfort of rail travel, this condition engenders a sense of well-being and security. It has been seen from experience that it is neither the amplitude of displacement nor its velocity, that produces a sensation of discomfort. Neither is it the acceleration; for a journey when performed at high speeds over curves of constant radii of curvature is not uncomfortable. In fact, it is the rate of change of acceleration, a phenomenon commonly known as jerk, which produces uncomfortable sensations.

EVALUATION OF RIDING QUALITIES

The term "Riding Quality" denotes, in the general sense, a measure of comfort. All vibrations that emanate from the movement of a vehicle and their reactions in regard to physical comfort form the basis of riding quality.

There is however no wholly quantitative basis for measuring the physical sensations and no specific universal standards as such by which the riding qualities can be assessed and evaluated, but a reference standard, called the "Ride Index", has been adopted by the Association of American Rail Roads to compare the riding qualities of their passenger Coaches.

Experimental investigations initiated by Meister of Germany and developed by several other authorities formed the basis of this standard. The experiments were carried out by subjecting groups of persons of various ages and temperaments to a series of vibrations and tests on a shake table and their reactions in regard to physical comfort were classified and numerical values laid down for each "Threshold" of sensation. A set of comfort curves derived from these experiments is shown in FIG: 1

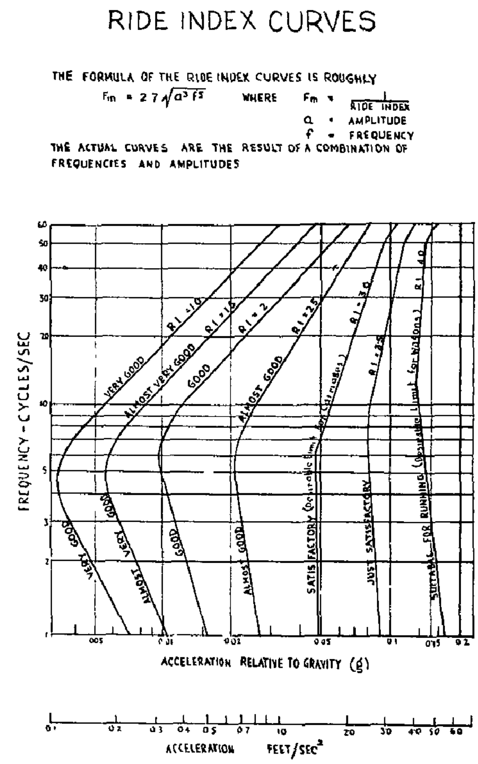


Fig. 1.

The problem of riding has been attacked from different angles in bogie designing since it is mainly governed by springing and its disposition. Good riding not only depends on the mechanical engineer but also on the civil engineer and may involve the electrical engineer as well.

The Mechanical Engineer is responsible for evolving a suitable design for the bogie while the civil engineer can help by providing a suitable track and maintaining it in good condition. For example it has been found that unevenness over rail joints and lateral track irregularities can both be reduced by butt-welding the rails. The effects of the lateral forces resulting from the swing of a carriage underframe carrying an added weight of dynamo and battery boxes, while negotiating a curve, cannot also be left out of consideration.

Another contributory factor, which often goes uncared for but is responsible for poor riding is the manner in which the stock in the train is marshalled. Coaches in a train with varied assemblies comprising light and heavy coaches, long and short, do not ride well. To obtain the best results, the stock should have similar characteristics such as bogie centres, overall length and weight. In this respect, the operating staff enter into the field

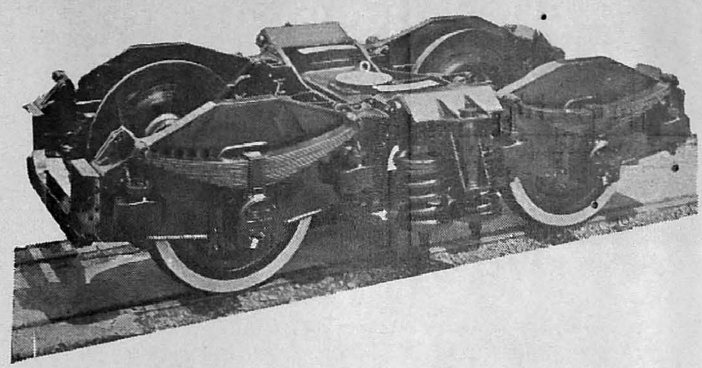


Fig. 2. A typical British bogie.

with the work, which is although non-technical nevertheless important.

DISTURBING FORCES

The disturbing forces which a coach is subjected to while in motion, are :—

(1) Pitching, i. e. the front and back ends of the vehicle alternately rising and falling about a transverse horizontal centre line.

(2) Rolling, i. e. transverse oscillation of the Coach on its springs, about a longitudinal centre line.

(3) Nosing, i. e. transverse oscillation on the track about a vertical axis, pursuing a sinuous path along the track.

The two movements viz : rolling and nosing rarely occur separately, but are generally found acting together in varying proportions. The resulting oscillation is termed hunting.

(4) Lurch — one semi-amplitude of movement in the action of hunting, viz., an individual deflection from the centre line towards one or other of the running rails.

(5) Shuttling — Oscillation of the coach in a fore and aft direction paralled to the track.

Pitching is generally caused by unevenness of track, hammering at rail joints by wheels, eccentric wheels and flat spots. If the period of disturbing force coincides with the natural frequence of the suspension spring, a condition of resonance is set up with resultant rough riding.

The vertical irregularities of track are mainly responsible for causing a tendency for a coach to roll and this is particularly noticed when the coach is at traversing points and crossings. Vertical irregularities are constituted by the conditions arising from wear of the rail head, unevenness at rail joints and the vertical variations in the travel of the wheel caused when traversing points and crossings.

Nosing is generally induced by the lateral irregularities of the track amplified by the natural motion of the wheel sets along a sinusoidal course when travelling over a straight track. Inaccuracy of bogie assembly and excessive play between the hornchecks and axle boxes and between the bolster and its rubbing blocks are other factors which cause nosing.

The fundamental causes that induce lurch are (a) defects in the alignment of straight tracks and irregularities in radius of curvature and (b) lateral shocks caused by variations in track gauge. The sinusoidal movement of the wheel set due to conal wheel units is another important factor responsible for inducing side lurch in a coach while in motion. Axle box clearances and clearance between wheel flanges and rail gauge faces, provided for in consideration of other factors, are additional causes which attribute to the lateral oscillations or side lurch in a vehicle.

Shuttling forces on a vehicle are generally produced by (a) variation in draw bar pull, (b) unbalance in wheel axle assemblies, and (c) varying accelerations of the vehicle. While movements due to items (a) and (b) periodic, the disturbances due to item (c) are irregular and mostly of a random nature. The frequency of oscillations caused by item (a) is equal to the frequency of the rotation of the coupled wheel of the locomotive and that due to item (b) is equal to the coach wheel rotation. It is obvious therefore that the coaches

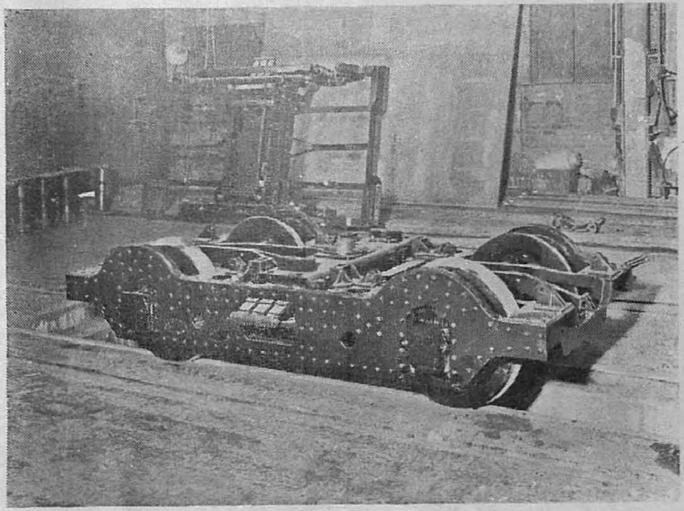
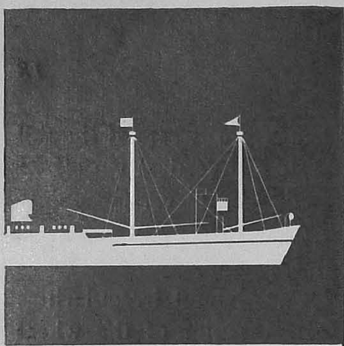
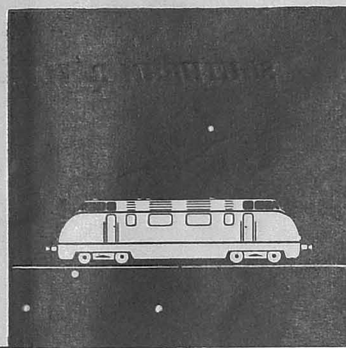
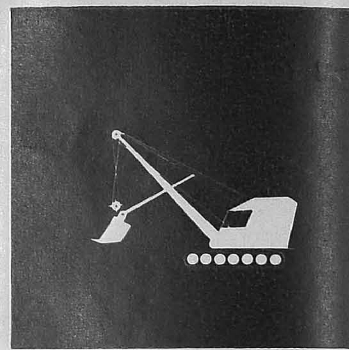
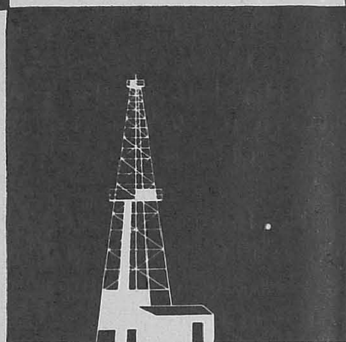


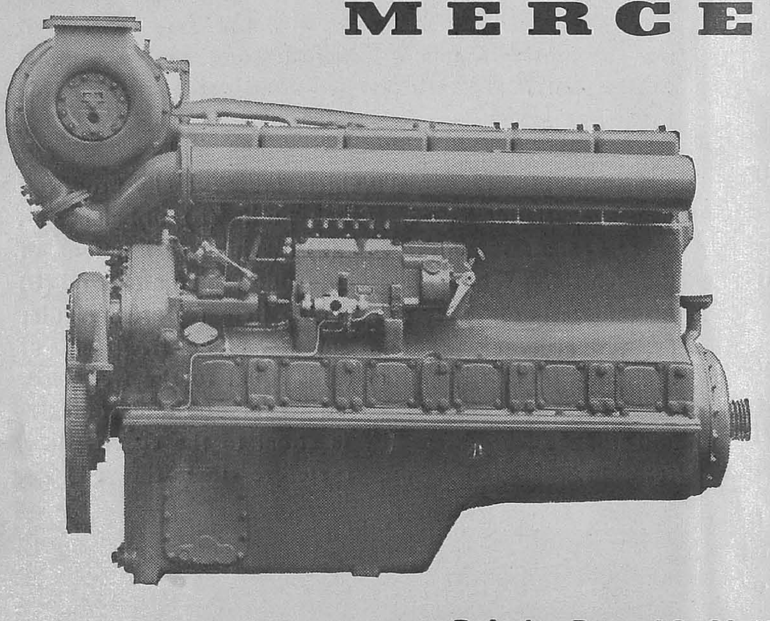
Fig. 3. A bogie showing the laminated elliptic springs under the bolster.











nearer the locomotive are subjected to greater shuttling effects induced by item (a) caused by the unbalanced reciprocating mass of the locomotive.

CONTROL OF DISTURBING FORCES

In designing the bogie, attempts to control the known disturbing forces have been generally on the following lines.

As an answer to the problem of pitching, the bogie has been designed with a spring-borne floating bolster sustaining the superimposed load on a central pivot and side-bearers. Further resilient liners of adequate thickness of vibration—absorbing material are interposed at bogie pivots, side-bearers and under-spring seats to insulate the underframe from the transmission of vibration emanating from the track and bogies.

The wide spring-base bolster and provision of two sets of springs, one consisting of spiral springs and the other of laminated springs contribute largely to control the rolling. The use of nests of coil springs mounted outside the bogie frame, as first devised by Kreissig and employed in a railcar built for I. G. Farben has been an attractive solution to control this movement, since when the body tends to roll, the springs on one side must control the roll by their compression action and the nearer the springs are to the longitudinal axis of the bogie, the stiffer they must be to control rolling and the less contribution can they make towards good vertical riding. It has been observed that a coach over bogies with the bolsters extended beyond the side frames and their springs disposed correspondingly farther outward, rides well.

Rolling is also controlled by the provision of side-bearers so that a part of the load could be transferred to an appreciable distance from the theoretical centre of rotation. The design of IRCA bogies in India may be quoted as an instance in point.

Where, however, this has not been done, a wide bearing in the middle round the bogie centre pivot is provided to distribute the weight from that centre over the axle boxes. This principle has been employed in designing IRS bogies adopted as standards by the Indian Railways.

The India Rubber body pads interposed between the carriage body and the underframe also serve the purpose of damping this movement while the coach is in motion.

It is not possible to eliminate nosing and lurch altogether as sinusoidal movement is fundamental to the bi-conal wheel unit designed principally to compensate to such extent as possible for the curvature while

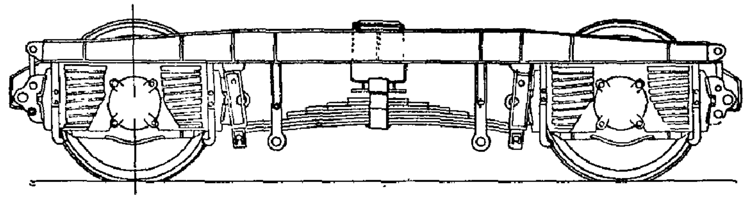


FIG-4 BOGIE OF SCHLIEREN COACH

running along the curves. Cylindrical-tread wheels or altering the wheel to a 1 in 100 cone instead of the 1 in 20 are although possible solutions and experiments carried out according, no finality has been reached in this connection due to following disadvantages associated with such proposals.

(a) With Cylindrical-tread wheel, if the flange gets against the rail it stops there until it strikes points. There is a tendency for it to run crab fashion. Turning a cylindrical-tread wheel accurately and no compensation for curves are the other disadvantages.

(b) With the coning of 1 in 100, the wheels under heavier stocks, will require more frequent tyre turning to maintain the effect as it has been found from trial that the treads wear very rapidly.

A much attractive solution lies in the reduction of the freedom of yaw of the axle. This was observed for some years in Britain in tramcar bogies. The reduction in the clearance between the axle box and the bogie frame to the bare minimum is another satisfactory proposition to arrest this movement in the type of bogie which has the axle boxes moving in horns.

Some people advocate the use of inclined bolster hangers to control hunting as with the inclination (as from top to bottom) provided, the bolster with its associated parts tends to return to a central position after deflexion. This inclination is also of advantage in counteracting body roll on entering curves. Others are of the opinion that inclined hangers set up oscillations and keep the coach body bouncing, causing excessive side movement, while straight hangers of a correct length will induce less side movement with a quicker, smoother return to the central position.

The reduced flangeway clearance, experiments in connection with which, were carried out in India during 1941, offers another satisfactory solution in this connection.

To improve riding qualities, the modern practice is to employ hydraulic shock absorbers for damping both vertical and side movement of the bogie and these have characteristics worth examining.

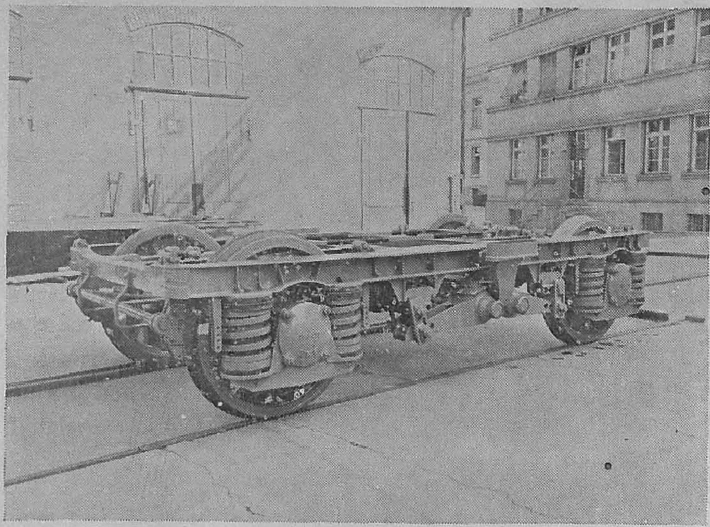


Fig. 5. Bogie springing arrangement according to the current Swiss practice incorporating lateral bolster torsion bars with helical axle-box springs.

BOGIE SPRING SYSTEM

From the mechanical point of view, two factors are vital which govern the riding qualities of a bogie, one is the form of tyre profile and the other is the springing and its disposition. The former has already been discussed in the preceeding paragraphs.

In practice it has been found that two sets of springs on a bogie, one consisting of spiral springs and the other of the laminated springs, yield good results. Spiral springs oscillate more readily than the laminated springs, as the friction of the plates in laminated springs helps to minimise rapidly any oscillation which may be set up.

There are two main practices in regard to the arrangement of such differentiated springs. The normal British practice (Fig. 2) is to support the bogie frame on laminated half-elliptic springs over the axle-boxes with spiral or rubber auxiliary springs at their ends and the bolster rests on spiral springs. The standard I. R. S. type bogie used on Indian Railways is related to the normal British practice.

In the other arrangement (Fig. 3), laminated elliptic springs are provided under the bolster and the bogie frame is supported by spiral springs on equalising beams resting on the two axle boxes.

TORSION BAR

A new line of bogie design, adopting a very simple element from automobile construction has been developed currently in Switzerland incorporating the torsion bar arrangement.

In this arrangement a bar of square or circular cross section is fixed at one end while the other end can rotate in a bearing and has a lever. Pressing on the end of that lever, the bar is distorted according to the force. When the force is omitted the bar turns back to its initial position. This elastic distorsion of the bar material constitutes an excellent springing.

The first application of the torsion bar for body springing was made in 1938 with the double-motor-coach BCFZe 4/6 Nr. 681 of the Bern-Schwarzenburg—Railway. Then followed in 1939—40, eight lightweight cars of the Rhætian Railways (Flying Rhætian) with torsion bar body springing. Seeing the good riding qualities, other railways in Switzerland gradually followed suit.

In the Schlieren type coaches recently placed on lines by the Indian Railways, the cross beam of the underframe rests on laminated springs which are in turn supported by swing links fixed to the bogie frame with freedom of lateral and longitudinal movement. The axle boxes are connected to the bogie frame by cylindrical guides surrounded by helical springs. The cylindrical guides are oil-filled and constitute a well lubricated guiding surface as well as being constructed as dashpots to control vertical oscillation of the springs. Fig. 4 depicts this arrangement.

In the latest construction as shown in Fig. 5, the functions of the laminated spring are taken over by two torsion bars secured at the bolster centre and connected at their ends to arms corresponding to the halves of the laminated spring. In this case there is considerable simplification in the bolster since the whole weight of the body is taken at the ends through rubbing pads leaving the centre pivot to be used only for centring. Adjustment is provided at the fixing points.

Although numerous attempts have been made to evolve a satisfactory design of the bogie incorporating different features, it can safely be stated without any fear of contradiction that finality in the matter of design has yet to be reached.

There is considerable room for further research in connection with the design of a bogie in general not to speak of in relation to its riding qualities only, although the course followed has been in the direction of better riding. The whole question appears to be in a state of flux throughout the world and it tends to advance slowly by evolution rather than by revolution.

HOW TO RESERVE ACCOMMODATION

Unless you reserve your berth (I Class) or Seats (II and 3rd Class long distance) in advance, you may not be sure of getting accommodation on the train you wish to travel by.

Application should be made to the Station Master of your starting station at least 3 days in advance specifying the date and train by which you intend travelling and the tickets must be bought in advance. The reservation fee leviable is 8 Annas per seat or berth.

Reservation by I and II Class from intermediate stations by Express trains can also be made similarly, but reservation ticket can be issued only after getting an advice from the Reservation Centre that the reservation has been made.

Tickets will be issued only if accommodation is available.

If the reserved seats or berths are not occupied at least 5 minutes before the booked departure of the train the reservation will be cancelled and the seat or berth given away to another.

Reservation fee is not refundable.

III Class seats are also reservable on Express and certain other important trains for long distance passengers from the train-starting stations on payment of a reservation fee of 4 Annas per seat.

Do not occupy a berth or seat reserved for another, as you are liable to be displaced at the last moment.

If you find another person occupying the berth or seat reserved for you and if he will not vacate it on demand, report it to the Guard or Station Master. They will help you.

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CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity; they are more important than medicines.

Cleanliness prevents disease; medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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