GLOUCESTER

GLOUCESTER RAILWAY CARRIAGE & WAGON CO LTD

ENGLAND



An Exhibition at Gloucester of

A NEW TYPE OF DIESEL RAILGAR OF TUBULAR CONSTRUCTION

designed and built for the British Transport Commission by the

Gloucester Railway Carriage & Wagon Co., Ltd., in collaboration with the

Transport Sales Development Department of T.I. (Group Services) Ltd.

19 JULY 1957

BRITISH TRANSPORT COMMISSION MULTI UNIT DIESEL STOCK

These Lightweight Diesel Mechanical Railcars of tubular steel integral design, forming part of an order for 80 vehicles ordered by British Transport Commission under their modernisation programme, have been designed and built by the Gloucester Railway Carriage & Wagon Co., Ltd. in collaboration with the Transport Sales Development Dept. of T.I. (Group Services) Ltd.

The cars, which are 57'-6" long, are required for suburban services and operate as twin sets, each set comprising one motor coach and one trailer coach (Fig. 1).

Each Motor Coach, powered by two 150 b.h.p., A.E.C., horizontal diesel engines under-floor mounted, has a 16'-0" luggage compartment, seating accommodation for 52 second class passengers, and a 4'-7" driving compartment.

The Trailer Coach also has a 4'-7" driving compartment with seating accommodation for 12 first class passengers immediately behind the driver, 55 second class seats, and one lavatory.

Heating is by two combustion type oil heaters supplying both recirculated and heated fresh air through ducting into the interiors.

The interior finish consists of plastic panels with timber mouldings polished natural colour. Comfortable bus type seats are installed.

General particulars of the vehicles are as follows:-

Length over body, motor and trailer car				 57'-6"	
Width over body, m	otor a	ind tra	iler ca	r	 9'-0"
Bogie Centres					 40'-0"
Bogie Wheel Base					 8'-6"
Wheel Diameter					 3'-0"

Tare Weights

Driving Motor	Coach	in	working	order	 	30 tons
Driving Trailer	Coach	in	working	order	 	25 tons

CONSIDERATIONS AFFECTING DESIGN

In order to obtain good acceleration characteristics for a loaded twin coach set using 150 b.h.p. engines it was desirable to pay particular attention to weight saving, at the same time retaining a robust construction to give long working life of the vehicles. With the engines mounted below the floor together with their gear boxes and auxiliary equipment, it was necessary to ensure a clean design of underframe in order to permit routine maintenance of the equipment to be carried out efficiently and quickly. An integral type of structure assembled from welded units was considered to be best suited to these requirements, incorporating also methods still within the scope of existing railway carriage workshop equipment and techniques.



The present British Railways C.1. Loading Gauge, with its constriction at platform level and maximum widths at seat level, indicates the problems faced by present day railway engineers desirous of designing a truly integral structure which will conform to this loading gauge.

The tubular design has unique features by which to overcome these inherited complications imposed by the C.1. load gauge, and it will be seen from the composite photograph of an exhibition quarter and sectioned pillar (Fig. 2) that the tubular pillar is built into the solebar, and the severe change in width is achieved by cranking the pillar at floor level.

Since during the life of a rail coach most structural members are called upon to act as struts, it was decided to take advantage of the superior elastic stability and torsional resistance of closed or tubular sections, thus saving weight.

Other factors influencing the design were the necessity for incorporating British Railways standard equipment including side buffers, screw couplings, bogies, gangways, brake gear, etc. Finally, it was considered necessary to design a coach structure suitable for breaking down into sub-assemblies, i.e. body sides, body ends, floor, roof, etc., which could be jig built.

Figure 2 Composite photograph of Exhibition Quarter and Sectioned Pillar.

BODY STRUCTURE Body Sides

In an integral body of this type it is important that the vertical loads due to structure weights, equipment weight and passengers, should be distributed into, and reacted by, the whole depth of the body side including the solebars. Structurally, a flat or slab body side is the ideal truss. The British Railways load gauge excludes this possibility since the width over panels is 9'-0" whilst the maximum width over solebars is limited to about 7'-11" (see sketch of C.1. Load Gauge—Fig. 3). The problem was further complicated because the change in width from 9'-0" to 7'-11" is not gradual, but takes place almost entirely at floor level.

The transfer of load from solebars in the body side was effectively achieved by cranking the pillar sharply at floor level, as shown in Fig. 2, and it will be seen that the pillar is actually built into the solebar to ensure efficient transfer of load without giving rise to sudden stress changes. Calculations show that the forces in the pillars are at maximum around floor level and determine the size of pillar sections in this area. At the cantrail, this size of pillar section was greater than necessary, and advantage was taken of the weight saving made possible, by using a tube whose wall thickness varies. Such tubes are known as butted tubes and are readily drawn commercially, being commonly used in bus seat side bends, steering columns of bicycles, etc. The tubular pillars incorporated in this coach structure are of

constant thickness over the bottom 18", and the wall thickness then tapers over a length of 12". Thereafter the thickness remains constant at the thinner gauge up to cantrail level. The use of this cranked butted tube for the body side pillar overcame the load gauge problem at solebar level, saved weight, and enhanced the stability and efficiency of the body side by permitting a good pillar attachment. A tubular pillar sectioned vertically is shown at Fig. 2.

For efficient use of metal, compressive strength and stability, tube was chosen to form the basis of a fabricated solebar. These solebars were built up as units (Fig. 4).

A stiff deep box was required to form the cantrail and this was fabricated from cold formed sections generally in Corten steel (Fig. 5). Considerable attention was paid to the connection of pillar to cantrail since this connection was required to transfer shear into the cantrail. The outside appearance of the body side is quite pleasing and, most important, the design provides a truly integral truss.

The framing members are joined by welding, with panels also attached by welding to form a unit.

Figure 3 Sketch of C.1. Loading Gauge.

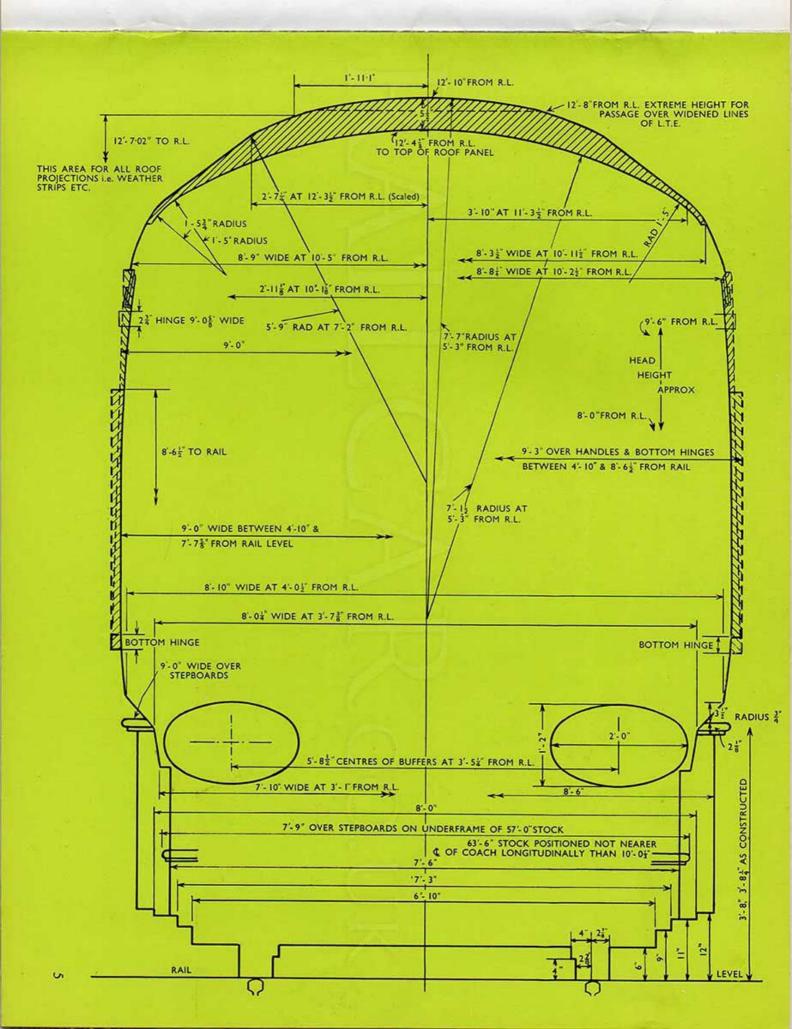


Figure 6 Corrugated Steel Floor Units.

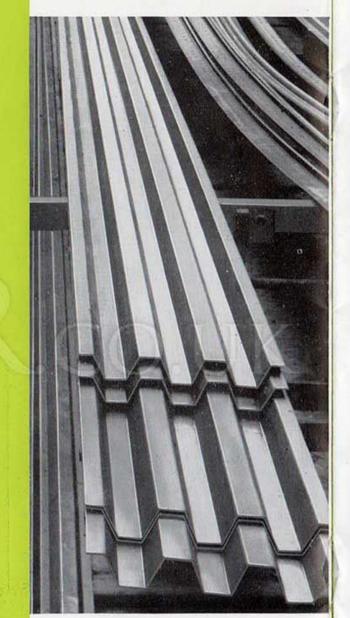
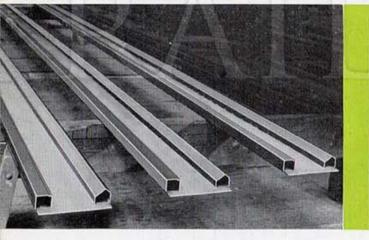
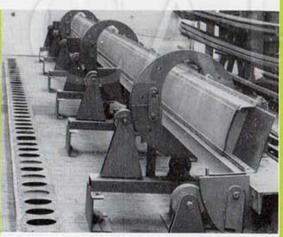


Figure 4 Solebar Unit.

Figure 5 Cantrail Unit.





Floor

There is no underframe in the normal sense, but the weight of metal usually concentrated in the centre longitudes is spread over the whole width of the floor in the form of corrugated steel sections with the corrugations running longitudinally. This corrugated steel floor (Fig. 6) is cold rolled in 57'-0" lengths to eliminate the difficulty of matching and welding up joints across the coach, to sustain both the buffing and draw loads, and also to support passenger load between crossbars. The bolster, headstocks and buffing gear support structures are built up as unit assemblies. Again for the purpose of light weight and strength, these units are fabricated from steel tube, sheet and plate, permitting the metal to be concentrated where it would do most work. Diffusion of buffing and draw loads into the corrugated steel floor is achieved by incorporating

tubular longitudes immediately behind the buffing and draw gear. In order to assist the diffusion of end loads into the floor, and to save weight, these tubular longitudes are tapered in wall thickness, the thickness being greater at the headstocks.

Body Ends and Roof

The body end and the roof between cantrails are built up in much the same way as on the standard British Railways coaches. With regard to the roof, it was felt that shear lag across the roof panels would reduce the effectiveness of incorporating extra framing or purlins, and therefore the cantrails were considered as the main load-carrying members.

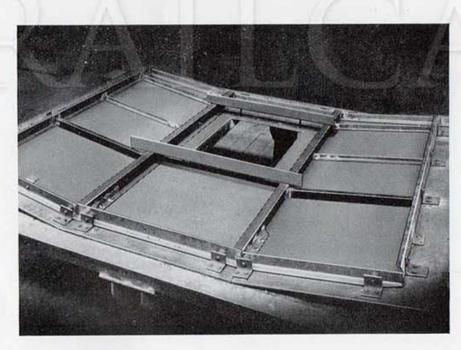


Figure 7 Body End Unit.

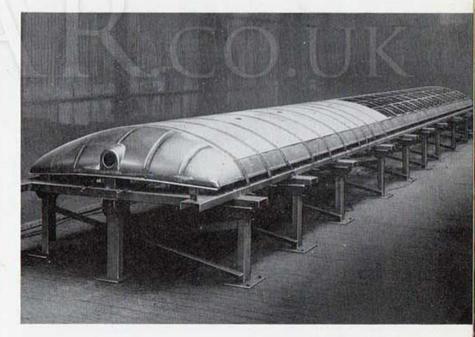


Figure 8 Roof Unit.

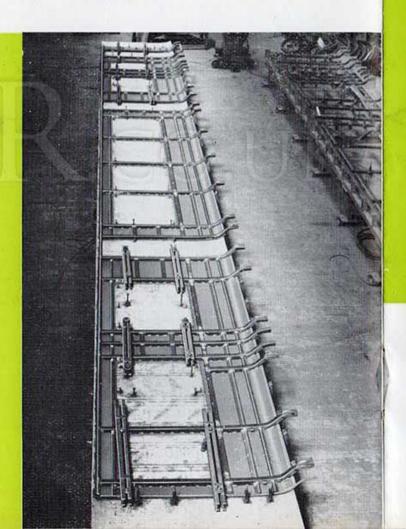
ASSEMBLY

The various components comprising the whole of the structure were assembled to form a complete unit by a combination of rivetting and welding designed to facilitate repairs being carried out on the frame without difficulty.

The following illustrations show components of the body in the jigs and fixtures used for production purposes:—

Figure 9 Body Side Unit.

- Figure 4 Solebar Section Figure 5 Cantrail Sections
- Figure 6 Corrugated Steel Floor Units
- Figure 7 Body End Unit
- Figure 8 Roof Unit
- Figure 9 Body Side Unit
- Figure 10 Underframe
- Figure 11 Bolster
- Figure 12 End Longitudinal



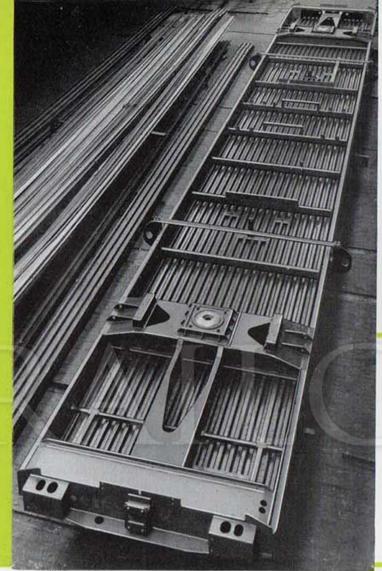


Figure 10 Underframe.

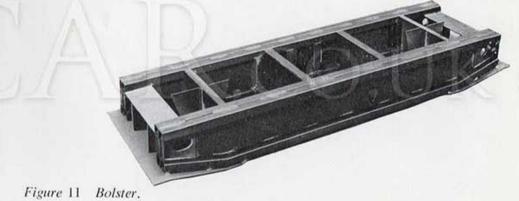
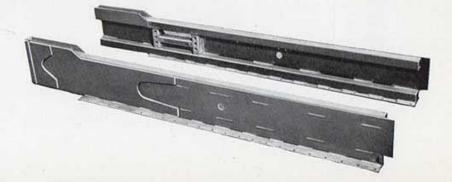
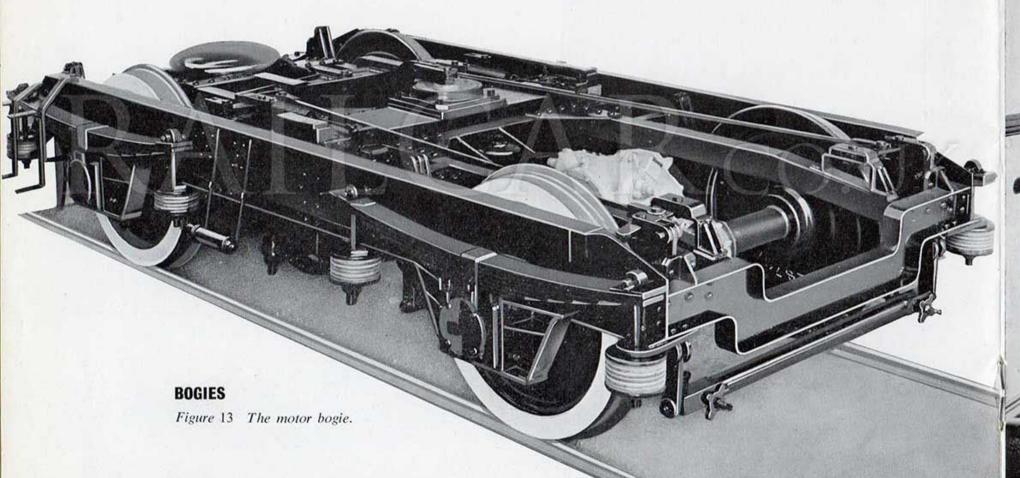


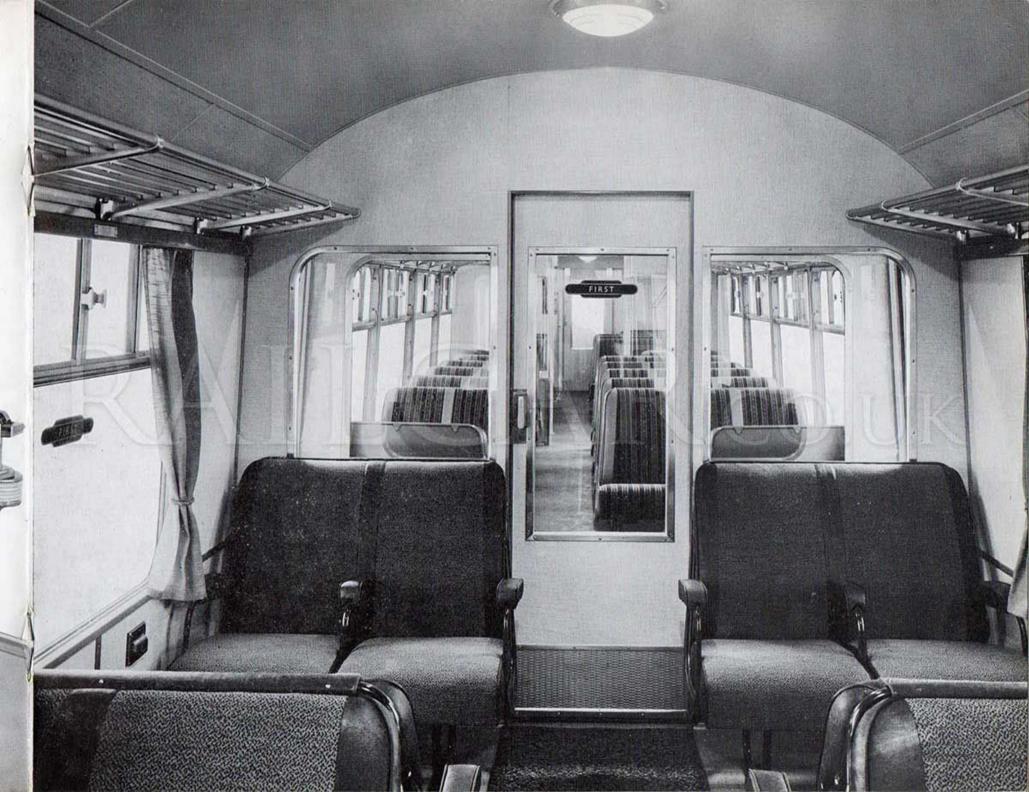
Figure 12 End Longitudinal.

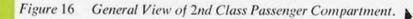


INTERIOR FINISH AND FURNISHINGS

Figure 14 General View of 1st Class Passenger Compartment.







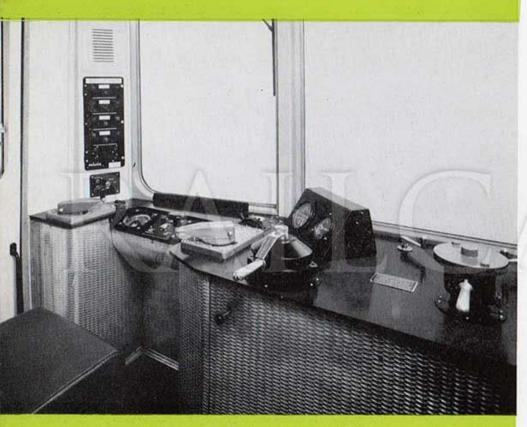


Figure 15 Motorman's Compartment.

INTERIOR FINISH AND FURNISHINGS

The interior is finished in plastic panels of pastel shades. Plastic covered blockboard windscreens with glazing in aluminium extrusions, and supported by stainless steel-clad tubular grabpoles, protect seated passengers from draughts at the doorways.

The floor above the deep corrugated steel sub-floor consists of cork sheets framed in timber and sandwiched between plastic sheeting on both sides to give sound insulation and immunity from rotting after prolonged service.

A general view of the passenger compartments is shown at Figs. 14 and 16, while the motorman's compartment is shown at Fig. 15.



STRENGTH TESTING OF COACH BODY STRUCTURE

In order to prove that the design satisfied the British Transport Commission strength requirements it was decided to test the coach body shell, using electrical resistance strain gauges to determine stress levels at selected points. For this purpose a shell was taken out of the production line and set up in such a way as to represent the actual conditions of body support which exist in service, and a special testing rig was erected for the purpose of applying a compression load to the side buffers.

Location of Strain Gauges on Structure

With reference to the stress analysis of the coach a total of 200 positions around the structure was selected for stress measurement. For applied vertical loads, theoretical analysis indicated that the most severely stressed regions would be in the solebar adjacent to the body bolster, the body bolster itself, the quarter, cantrails and solebars framing one of the doors between bogic centres (Fig. 17). Additional gauges were located across the floor and roof midway between bogic centres, and at the door openings mentioned above. Gauges were also applied to the quarter immediately above the bolster (Fig. 18), since it was desired to ascertain the force distribution in this region of the coach.

Under an end buffing load, the most highly stressed parts indicated by theory are the solebars, the tubular longitudes immediately behind the side buffers, and those supporting the centre couplers, and the horizontal beam between the lower solebar tubes immediately behind the headstock. As

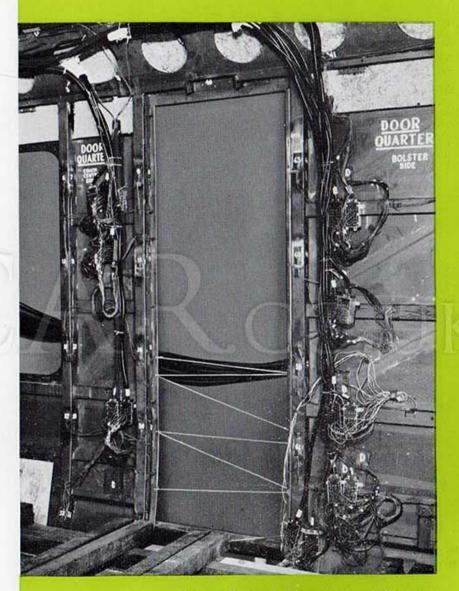


Figure 17 Strain Gauges around Doorway.



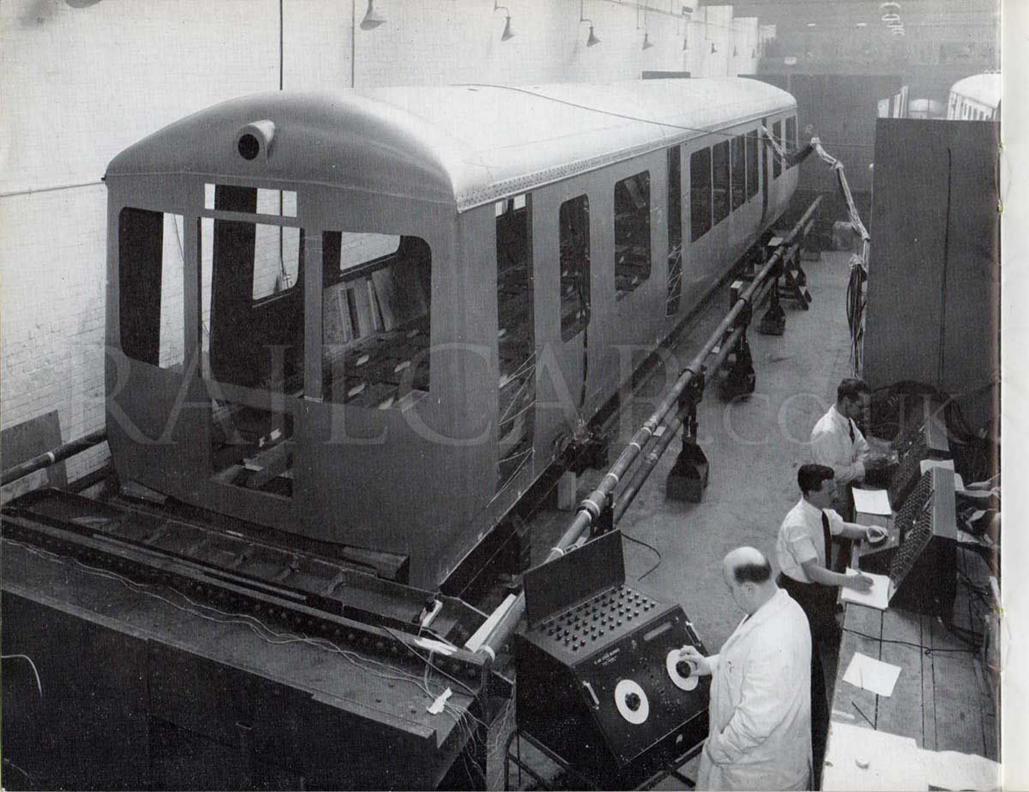
Figure 18 Strain Gauges on Bolster Quarter.

it was also desired to study the behaviour of the corrugated floor under buffing load, gauges were located on this floor in such a way as to ascertain both the stress distribution across the floor, and the load diffusion into the floor from the butted tubular longitudes. Fig. 20 shows some of these gauges on the corrugated floor.

Loading System and Strain Measurement

The vertical load was applied by iron bars laid in the coach to represent a distributed passenger load. The end buffing load was applied by means of a hydraulic ram at the driving end of the coach, acting on an equalizing beam which in turn acted on the side buffers. Another beam on rollers was held against the buffers at the non-driving end of the coach by means of a total of four circular section tie bars running the length of the coach and reacting the ram thrust of the driving end. A series of strain gauges was attached to these tie bars to measure the force exerted by the ram, which was also checked by pressure gauge. Signals from the electrical resistance strain gauges on the coach structure were measured by two 100-way Static Strain Recorders designed and made by the Gloster Aircraft Co., Ltd. These instruments are seen in Fig. 19, which also shows the equipment for applying the buffing load in place on the coach.

The signals from the gauges on the four tie bars were read on a Savage and Parsons 50-way Strain Recorder, seen in the foreground of Fig. 19.

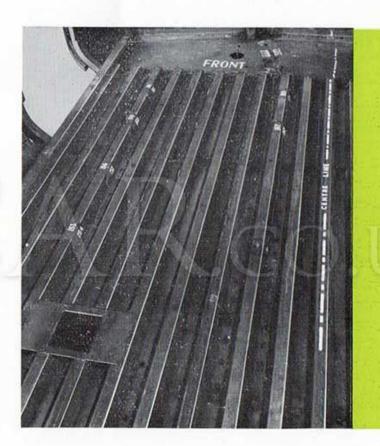


Test Results

The test programme included the following loading cases:—

- (a) A uniformly distributed load of 17½ tons, 15 tons of which was applied and removed a minimum of five times during the course of the test programme.
- (b) An end buffing load of 80 tons which was applied and removed a minimum of five times during the course of the tests, a uniformly distributed load of 2½ tons remaining in the coach as a settling vertical load the whole time.
- (c) A combination of the above, i.e., a total uniformly distributed load of 17½ tons together with an 80 ton buffing load. This combination was applied once.

In order to ensure absolute reliability of the test results, staff from Tube Investments Technological Centre who were in charge of the test found that it was necessary to work the structure for a number of cycles by applying and removing the maximum vertical and buffing loads several times. After such working of the structure the strain readings were not only linear (except for a very few lightly loaded points) but were consistent with each repeat of test.



◆ Figure 19 General View of Shell under test.

Figure 20 Strain Gauges on Floor

For each case (a) and (b) above, the test proper was carried out three times, a complete set of strain readings being taken at various load increments during each test run.

A complete and detailed analysis of the results would be too lengthy to set down in full here, but the following items are of interest, especially when considered in relation to certain design features of the coach body structure.

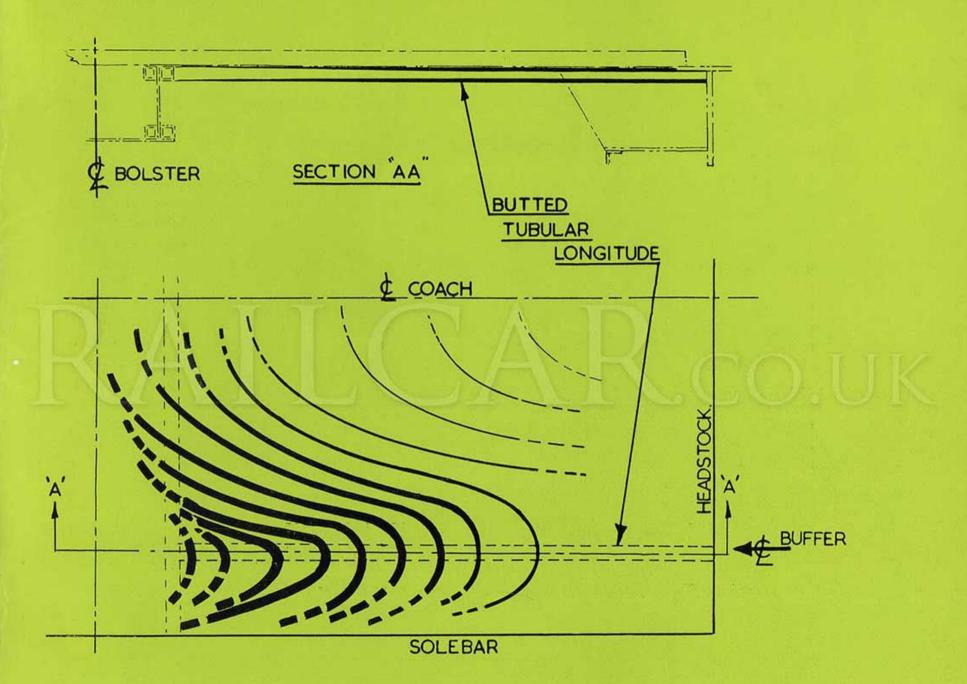
The attention paid to the joints of pillars to solebars and cantrail, together with the use of butted tubular pillars, was justified, since the vertical deflection of the coach at the solebars, midway between bogic centres, under a load of 15 tons, was only 0.13", and the inward movement of the body sides at the waist rail of the bolster quarter, door quarter, and single pillar at the coach centre line was 0.0312", 0.0548" and 0.101" respectively. These figures combine to show that the applied loads were reacted by the whole depth of the body side without distortion of the coach cross sections. Further, the stresses recorded in the pillars did not show any sudden change of stress level around the crank at the solebar.

The gauges located on the corrugated floor and the

buffing gear support structure, showed that the butted tubular longitudes immediately behind the buffers diffused the end load into the whole width of the floor very efficiently. Fig. 21 illustrates this diffusion of load into the floor from the tubular longitude, each curve representing a certain compressive stress value, the thicker the line the higher the stress level. It will be seen that at the centre-line of the bogie the compressive stress level is approaching a more or less uniform value over the whole width of floor.

The applications of the combined vertical load and 80 ton buffing load caused the coach to contract elastically 0.46" over its length and no part of the structure suffered any permanent set. The conclusion which may be drawn from the whole test programme is that a still further saving in structure weight may be achieved without any marked increase in the general stress levels at any point, and without introducing elastic stability or stiffness problems. The percentage of structure weight to finished weight of a motor car is only 20%. Any further large reduction in vehicle weight therefore cannot be expected from the structure alone.

Figure 21 Stress Pattern in Floor.



RAILCAR CO.UK

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With Compliments

Gloucester Railway Carriage & Wagon Co., Ltd.
1 Albemarle Street,
London, W. 1.

GROSVENOR 8206

BRITISH TRANSPORT COMMISSION DIESEL RAILCARS.

A3 TYPE DIESEL MOTOR CAR.

B2 TYPE DRIVING TRAILER CAR.

SUPPLEMENT TO GENERAL BROCHURE.

PARTICULARS OF TRACTION AND OTHER EQUIPMENT.

ENGINE: -

Two 11.31 litre horizontal 6 cylinder, in-line, compression ignition type AEC Engines. Power Rating 150 B.H.P. at 1800 r.p.m. Fluid Flywheel.

Each engine having a 2-cylinder Clayton Dewandre Air Compressor giving air at 80 to 85 lbs. sq. in. Fuel Consumption per car (2 engines) 3 m.p.g. Compression ratio 16:1.
Oil Pressure 50 lbs. sq. in.

A free-wheel is incorporated in each propellor shaft between engine and gearbox.

GEARBOX: -

Two Epicyclic type, 4-speed, Gearboxes.

The final drive is mounted on the inner axle of each bogie between the wheels.

FUEL TANK: -

Two Fuel Tanks each of 95 gallon capacity (80 gallons for each engine and 15 gallons for each heater). Giving approximate range of car 480 miles.

CONTROLS: -

All control being electro-pneumatic operated.

BRAKEWORK: -

Each car has two 18" Vacuum Brake Cylinders.

The Railcars are fitted with the Gresham and Craven Quick Release Brake System.

Two rotary exhausters, belt driven from the engines are fitted to each power car and these are lubricated by a common oil separator.

ELECTRIC LIGHTING: -

A Stones' Generator, engine driven, on power car and axle driven on trailer car, provides power for lighting. Each car has 12 - 2 volt B.R.A. 2 Type cells with 460 amp.hour capacity.

HEATING SYSTEM: -

This system comprises two 24 volt Smiths Combustion Oil Heaters per car. One using recirculated air, the other fresh air. Minimum air flow through heater ducting is approximately 300 cubic feet per minute.

Power car Seating Capacity 52 - 2nd Class.

Trailer Car " 54 - 2nd Class. 12 - 1st Class.

Exterior Panels "Corten" Steel, Body Pillars, Fortiweld Tubing. Crossbars, Solebars etc. "B" quality tubing.

INTERIOR FINISH

Plastic bonded on hardboard. Grabpole Stainless Steel. Metal fittings brass matt chrome finish or aluminium alloy anodised. Ceiling panels of "Laconite".

FLOOR:-

Cork Sandwich Floor, i.e. - 1/16" plastic with 3/4" cork between in timber frames, laid on steel trough sections.

CAR WEIGHTS

				101
POWER CAR	T.	c.	q.	lbs.
Body Shell	6	7	3	0
Engines and Engine Equipment	3	5	0	17
Other equipment and general interior finish	9	4	0	5
Fuel and Water	-	7	0	16
Bogie - Driving	5	11	0	10
Trailing	5	9	3	8
TOTAL WEIGHT OF MOTOR CAR	30	5	0	0
TRAILER CAR				
Body Shell	6	7	3	0
Other Equipment and general interior finish	8	8	0	18
Heater Fuel and Water	_	5	1	0
Bogie - With Dynamo	4	19	3	0

14

15

24

0 10

0

Without Dynamo

TOTAL WEIGHT OF TRAILER CAR