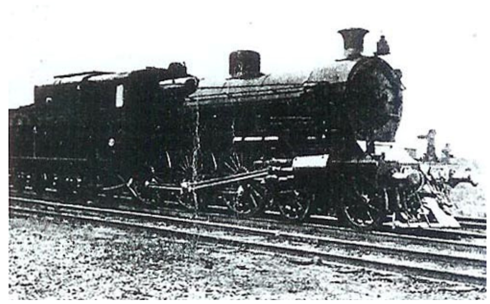
From “Hudson Power” by Robert Carlisle and Bill Abbott

published by the Australian Railway Historical Society Victorian Division in 1985 (ISBN 0 85849 028 5)
Transcribed by Chris Newman July 2013

Chapter 9 - R707 Conversion to PBC Dust Firing

The Victorian Railways experience in the use of pulverised brown coal dust (PBC) for locomotives dates back to 1923-24 when over a two year period, extensive tests were carried out with Yallourn open cut brown coal, using A2 class 4-6-0 No. 800, C class 2-8-0 No. 16 and DD class 4-6-0 No. 1022.



A2-800 as converted in 1923 to burn pulverised brown coal (STATE TRANSPORT AUTHORITY)

The C class tender which was used in rotation on all three locomotives was fitted with American fuel burning equipment known as the Fuller-Lehigh system which used pulverised brown coal briquettes or briquette material. Whilst the tests demonstrated that pulverised brown coal having a calorific value of 9,500 Btu/Ib could be used in a locomotive, the VR concluded that the engineering technology of the day was not sufficiently advanced to justify its large scale application to conventional steam engines.

The 1920s had seen a renewed interest in the application of various solid and fossil fuels to steam locomotive technology. The VR PBC tests of the time were in fact paralleled in New South Wales, Great Britain and Europe.

In 1920 the New South Wales Government Railways undertook a series of pulverised coal tests utilising the Fuller-Lehigh system installed on an S class 4-6-4 tank engine. Despite the use of high grade black coal fuel consumption was excessive due to the small volume of the firebox which prevented complete combustion.

During 1922 the Great Central Railway (UK) at their Gorton Works undertook a number of pulverised coal firing tests initially under the auspices of the then CME J.G. Robinson. The tests were continued briefly by R.A. Thom, who succeeded him in 1923 as District Mechanical Engineer, under the amalgamation arrangements which saw the formation of the London and North Eastern Railway.

In 1929 during discussions at the Institution of Mechanical Engineers, R.E. Maunsell, then CME of the Southern Railway, indicated that he intended to undertake pulverised coal testing. Professional opinion was clearly divided however as O.V. Bulleid (then assistant to H. N. Gresley, CME of the LNER) could not convince his mentor of its practical application to a steam locomotive despite the hypothetical advantages of the system including single man control, fully automatic firing and the virtual elimination of ash and clinker.

Bulleid, who was to become arguably one of the most brilliant and innovative CMEs of all time, was probably indulging in a bit of lateral thinking. The more conservative and cautious Gresley no doubt recalled the dust problems encountered during the earlier Great Central tests and could see the very real difficulties in marrying an advanced technology to the conventional steam locomotive, and more to the point make it an economical proposition.

Nevertheless during the 1930s significant progress was made by the German Federal Railways in operating ten locomotives of class G12 (tractive effort 53,000 lb) and G82 (tractive effort 42,000 lb) with brown coal dust derived from the electrostatic separation of dust passing up the dryer chimneys of briquette factories.

Following the end of World War 2, the Victorian Government decided to investigate further the development of Yallourn brown coal for industry and in particular railway usage. The development of an independent source of coal was given a high priority at the time as supplies of black coal were subject to interruption due to labour disputes on the New South Wales coalfields. In addition, much of the black coal supplied was of indifferent quality and often unsuitable for locomotive purposes.

The local precipitated dust was considered superior to that produced by the pulverisation of briquettes because of its lower moisture content of 6% as compared with 14% of processed brown coal and its higher calorific value of 10,400 Btu/lb. It did have the disability, however, of being coarser than the accepted standard for locomotive firing with nearly 50% of it being retained on a No. 170 British Standard Sieve as compared with the 'not more than 20%' specification of the German State Railways. Notwithstanding its coarseness, the dust did not affect the success of the system eventually developed by VR.

(The term 'PBC firing' originally related to the 1923 tests insofar as it stood for 'pulverised brown coal' derived from briquettes. However, in the 1949 test program the VR continued to use the same abbreviation and terminology in its own technical reports even though PBC now stood for 'precipitated brown coal' dust firing.)

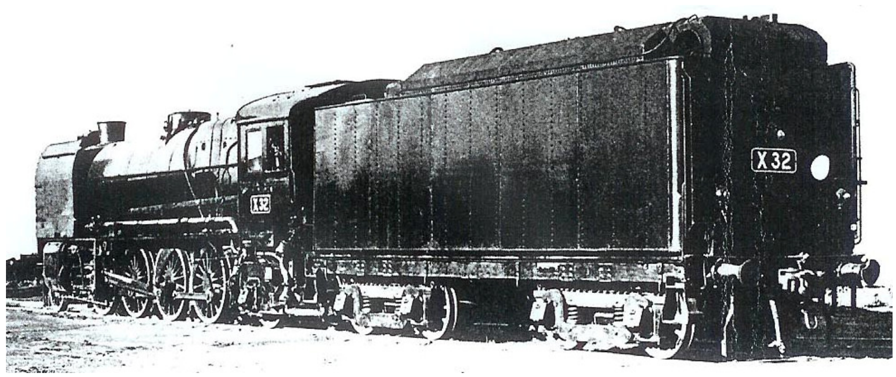
Consequently in 1946 the VR Commissioners sent Messrs W.O. Galletly and W.H. Chapman of the Rolling Stock Branch to West Germany to carry out further research on PBC technology with a view to initiating a large scale conversion of the VR fleet to burn local precipitated brown coal dust.

Investigations revealed that the German experiments with equipment supplied by the Studiengesellschaft (Stug) organisation, which had been developed principally by Henschel and Sohn of Kassel, had proved the most satisfactory under service conditions. Two sets of pulverised brown coal firing equipment were subsequently ordered from Henschel, arriving in Melbourne on board the *SS Port Napier* on 14th October 1948.

Initially it was proposed to convert heavy Mikado X52 which had been issued to traffic on 14th February 1947. However on 3rd November 1948, X32 was selected as it was to be shopped for a thorough overhaul and fitted with a new all-steel boiler. Following conversion in July 1949 the first road test was made to Woodend on 3rd October 1949 with a load of 385 tons including the dynamometer car. Runs were subsequently extended to Bendigo hauling 650 tons on the regular X-class schedule of five hours for the 100 miles including stops.

The road tests revealed that the PBC burnt cleanly and quickly despite it having a lower calorific value of only 10,400 Btu/lb compared with the 13,000 to 14,000 Btu/lb of the best NSW black coal. The better combustion of the almost talcum-like powder resulted in excellent steaming and quick response to power demands.

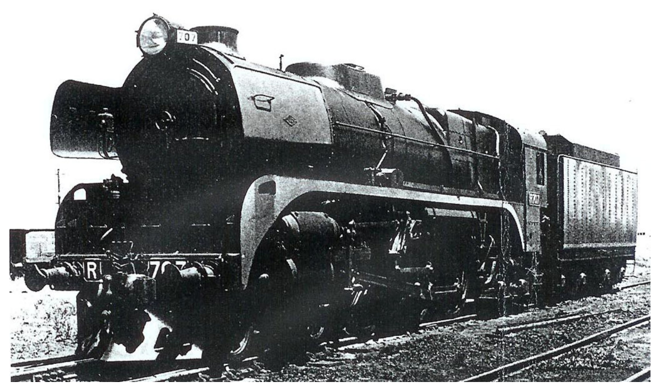
The operation of X32 on the North Eastern main line resulted in a marked improvement in sectional and overall running times. On a south-bound run from Seymour the engine was recorded to have taken 105 minutes for the 61¼ miles with a trailing load of 621 tons compared to the 147 minutes allowed for a full load of 650 tons for a black coal-fired member of the class.



X-32 showing turbine housing and PBC dust bunker shaped to fit within the loading gauge.
(STATE TRANSPORT AUTHORITY)

Following the successful operation of X32 on the test train between Melbourne and Bendigo and then in regular service on passenger and goods trains between Melbourne and Seymour, the VR decided in 1951 to similarly equip the remaining twenty-eight engines in the class. However, before embarking on a wholesale conversion program of the X class and other suitable wide firebox engines, a trial of the 'Stug' system on another class of engine was suggested for the second set of equipment.

Initially it was proposed to convert N138 (renumbered N428 in 1950), a light lines 2-8-2 engine which had been issued to traffic in 1931. However as the boiler proportions were subsequently considered unsuitable for PBC firing one of the post-war combustion chamber N class, twenty of which were then on order from Newport Workshops, was earmarked for conversion. The conversion was subject to the State Electricity Commission being able to initially supply up to twenty-eight tons of PBC dust per day. It was then proposed to use both engines intensively on briquette trains on a daily round trip between Yallourn and Melbourne with the regular roster of drivers for an extended service trial to ascertain their performance under normal operating conditions.

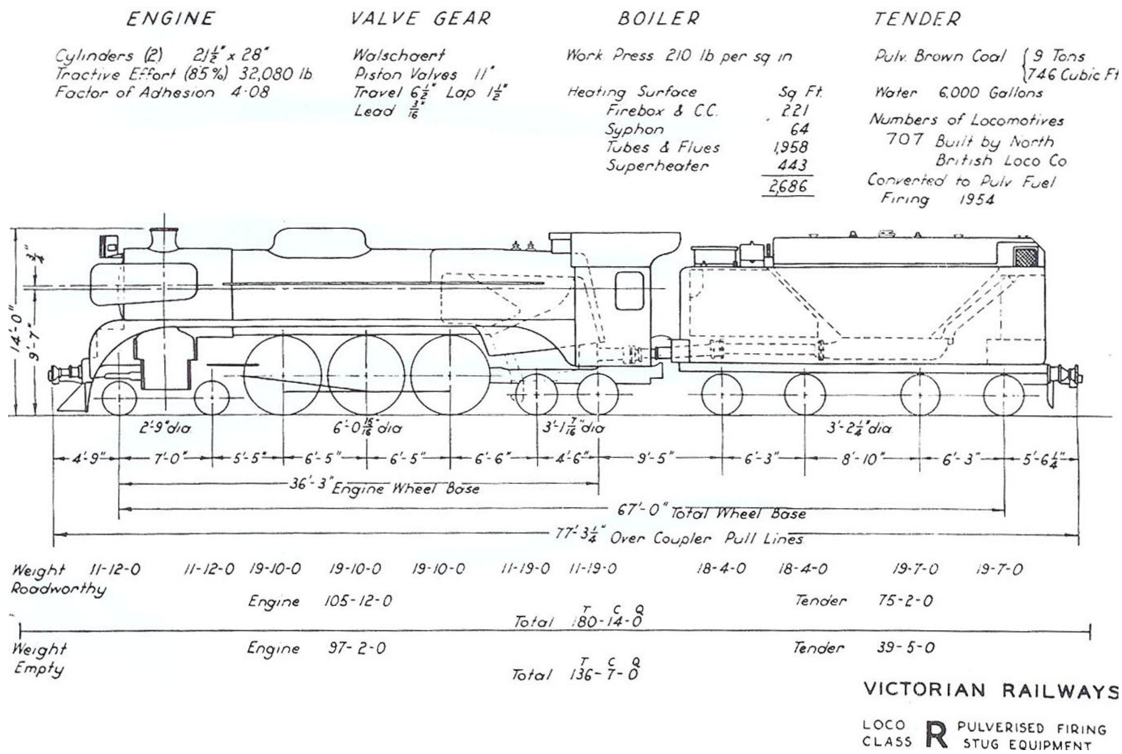

R707 at North Melbourne Loco Depot prior to release into traffic as a PBC dust-fired engine, August 1954 (STATE TRANSPORT AUTHORITY)

In September 1951 the CME directed the Rolling Stock Engineer's office to consider the conversion of an unspecified number of R-Class to burn brown coal briquettes. Whilst drawings were produced for alterations to the stoker front elbow and vertical housing, including the fitting of Hulson firebars and an Anderson front-end spark arrester, the project did not proceed beyond a preliminary design stage. However, in early 1952, it was finally decided to convert to PBC firing R707 which lay at Newport in a semi-stripped condition. The engine had arrived in July 1951, and not been issued to traffic due to the need to replace the complete leading coupled wheel assembly owing to major alignment defects. In addition, the engine had also suffered extensive damage to the coupled wheel axlebox bearings due to the ingress of salt water during the sea voyage to Australia. This required pressing off the axles of all driving wheel centres, fitting replacement roller bearings and rebalancing the wheel sets upon reassembly.

The R class was also selected because of it being able to sustain a high fuel consumption and its general suitability (Table 23) for pulverised brown coal firing having a large firebox and combustion chamber which gave the required furnace volume and flame length necessary to achieve complete combustion. Another advantage was that its equipment could be made the same as the thirty modified sets proposed to be purchased for conversion of the X-Class.

Fig 18

Pulverised Fuel Firing – R Class – Diagram of Principle Weights and Dimensions



In view of the apparent success of the 'Stug' firing system the VR Commissioners held detailed discussions in early 1952 with both the State Electricity Commission and the State Government to explore the economics of converting up to thirty-five modern wide firebox steam locomotives a year. The cost benefit study envisaged the conversion of a total of 214 engines, comprising forty-four X-Class including fifteen then to be built by Clyde Engineering in NSW, the seventy R-Class and 100 light lines N-Class (being the thirty Newport Ns dating from 1925, the post-war order for a further twenty Ns from Newport Workshops and the fifty North British Ns delivered in 1950-51). The estimated cost to convert the seventy R-Class was £637,000 or £9,100 per engine compared with a unit cost of £7,900 for the 100

N-Class. The study did not however include the cost of reboilering the 1925 batch of Ns with combustion chamber boilers.

The study was undertaken subject to the SEC being able to supply up to 60,000 tons per annum of PBC dust upon the commissioning of four new briquette factories in the Latrobe Valley by 1954. The output of PBC dust from these factories was estimated to have been sufficient to run thirty suitably equipped locomotives. In addition, long range projections envisaged an ultimate railway demand exceeding 200,000 tons of brown coal dust per year.

However, following the commissioning of only two of the briquette plants and the outstanding success of the B-Class 1,500 hp diesel-electric locomotives which had been introduced from July 1952, the Commissioners reviewed future VR motive power requirements in early 1954.

The haulage capacity and high utilisation of the B-Class locomotives on both passenger and goods services, had shown a marked economy in operating costs over steam locomotives and this led to the historic decision to dieselise the system as quickly as Commonwealth loan funds permitted.

It had become obvious that the heavy capital expenditure necessary to convert further wide firebox steam locomotives, construct additional overhead refuelling bunkers at twenty-one locations throughout the State and provide sophisticated fuel hopper wagons for transport of the dust from Yallourn could no longer be justified. In addition, first-grade NSW steaming coal was becoming available at attractive prices and residual oil fuel had become cheaper, as it was now being produced as an end-product by local oil refineries. This was at a time when brown coal dust had doubled in cost and operating experience with X32 had shown a significant increase in maintenance costs of the special burners, blowers and pressurising devices required over that applicable for comparable conventional steam locomotives.

As the diesel fleet was demonstrating marked operating economies over steam and the two non-standard locomotives required extra crew training and had limited route availability due to the lack of specialised refuelling facilities, the decision was taken to review the PBC conversion program.

Table 23

Relative Suitability of Locomotives for PBC Firing

Class of Loco	Grate Area (square feet)	Firebox Volume (cubic feet)	Evaporative Heating Surface (square feet)	Calculated Evaporation lb/hr	Approximate Flame Length (feet)	Ratio: Evap. Heating Surface / Firebox volume
R	42	242	2,243	35,650	25	9.25
X	42	234	2,615	36,690	22	11.1
N (SG)	31	174	1,453	24,000	21	8.35
J	31	128	1,444	21,180	19½	11.3
German G12	40½	212	2,063	28,000	19	9.7

In March 1954 the VR Chairman wrote to the Chairman of the SEC advising that:

> In connection with our likely demand for pulverised brown coal over the next few years, I would like to advise that the position has changed substantially since early 1952 when it was thought that our

requirements would progressively increase to 225,000 tons per annum by 1959. Since then, the introduction of diesel locomotives on main line services has absorbed much of the running previously done by the X and R classes of steam locomotives centred at Melbourne and forced them to operate in areas more remote from the source of supply of pulverised brown coal.

In addition the price of oil has reduced considerably and is still falling, while the cost of Yallourn precipitator dust has increased to such an extent that economics now favor the conversion to oil-firing of the locomotives that were originally listed for pulverised brown coal firing.

Consequently, we now propose to restrict our activities with the pulverised brown coal firing of locomotives over the next few years to an extension of current research. Locomotive X32 will continue to run and it is anticipated that a converted R class locomotive will be placed in service by about June 1954. The combined requirements of these two locomotives should not exceed 3,000 tons of precipitator dust a year at the inception and it is unlikely that this figure would rise above about 6,000 tons within the next five years if any further locomotives were converted.

Naturally I will keep you informed of any developments as they occur and have asked Mr. Galletly to keep your representatives on the inter-departmental Committee up-to-date of the current position insofar as this Department is concerned.

The fitting of the 'Stug' equipment to R707 at a cost of approximately £15,000 did not appear to have been given a high priority and the engine was not in fact issued to traffic as a PBC engine (Fig. 18) until 4th August 1954, some three years after its arrival from Britain. Modifications made to the engine included the following works:

- **Alterations to the Firebox:**

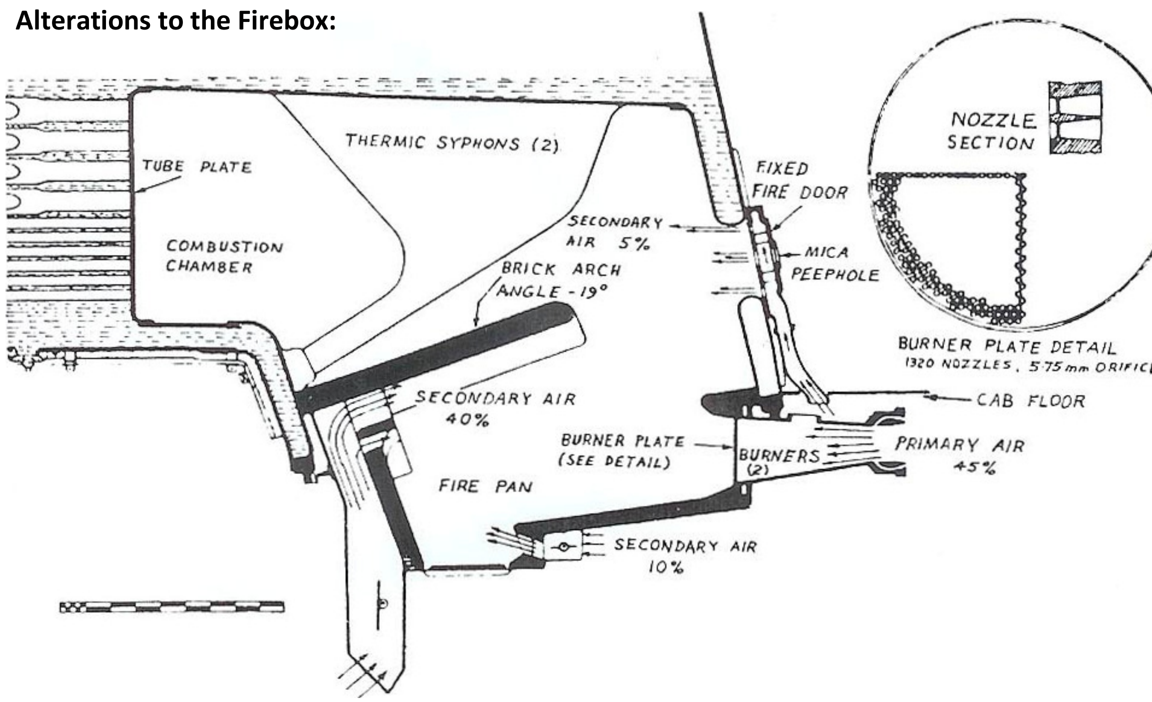


Fig 19
Firebox Arrangement – PBC Firing

Remodelling of the locomotive firebox (Fig. 19) was necessary to accommodate the 'Stug' burner equipment. The brick arch, which was of greater length than normal and at a reduced angle of nineteen degrees, was located at the throat plate and beneath the arch tubes and thermic siphons.

The normal grate and ash pan were replaced with a special fire-brick lined fire-pan below the foundation ring level with a firebrick horizontal deflector immediately over the burners.

As only 45% of the primary air was provided by the blowers through the burners the firebox brickwork incorporated dampers to admit secondary air into the bottom of the fire-pan through a forward-facing orifice (10%), underneath the brick arch (40%) and around the firedoor (5%). These dampers were designed for progressive combustion of the fuel and to prevent the intense heat of combustion from burning away the brickwork in the arch. Both dampers were inter-linked and operated from the one control lever situated in the cab in the normal manner.

In view of the high superheat temperatures experienced in the operation of X32 and the resultant difficulty in maintaining piston packing, it was also decided to reduce the length of R707's superheater elements by one foot to fifteen feet prior to its release into traffic.

- **Tender Modifications**

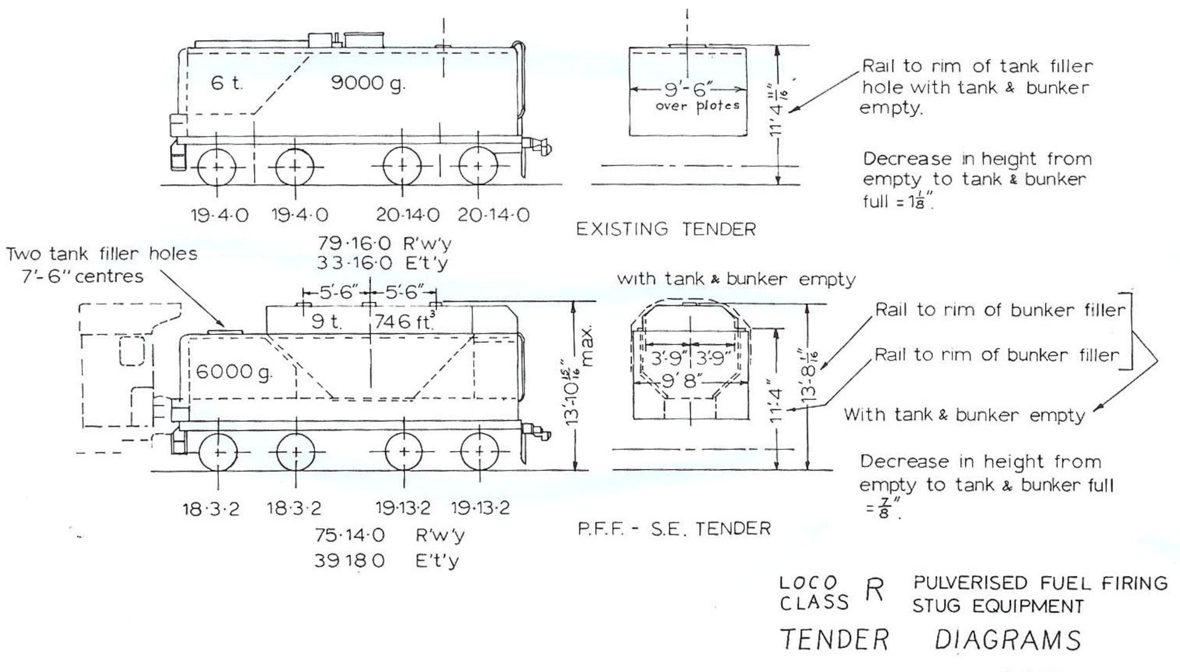


Fig 20

Tender Arrangement – PBC Firing

A completely reconstructed tank and hopper (Fig. 20) was fitted to the standard tender underframe and bogies.

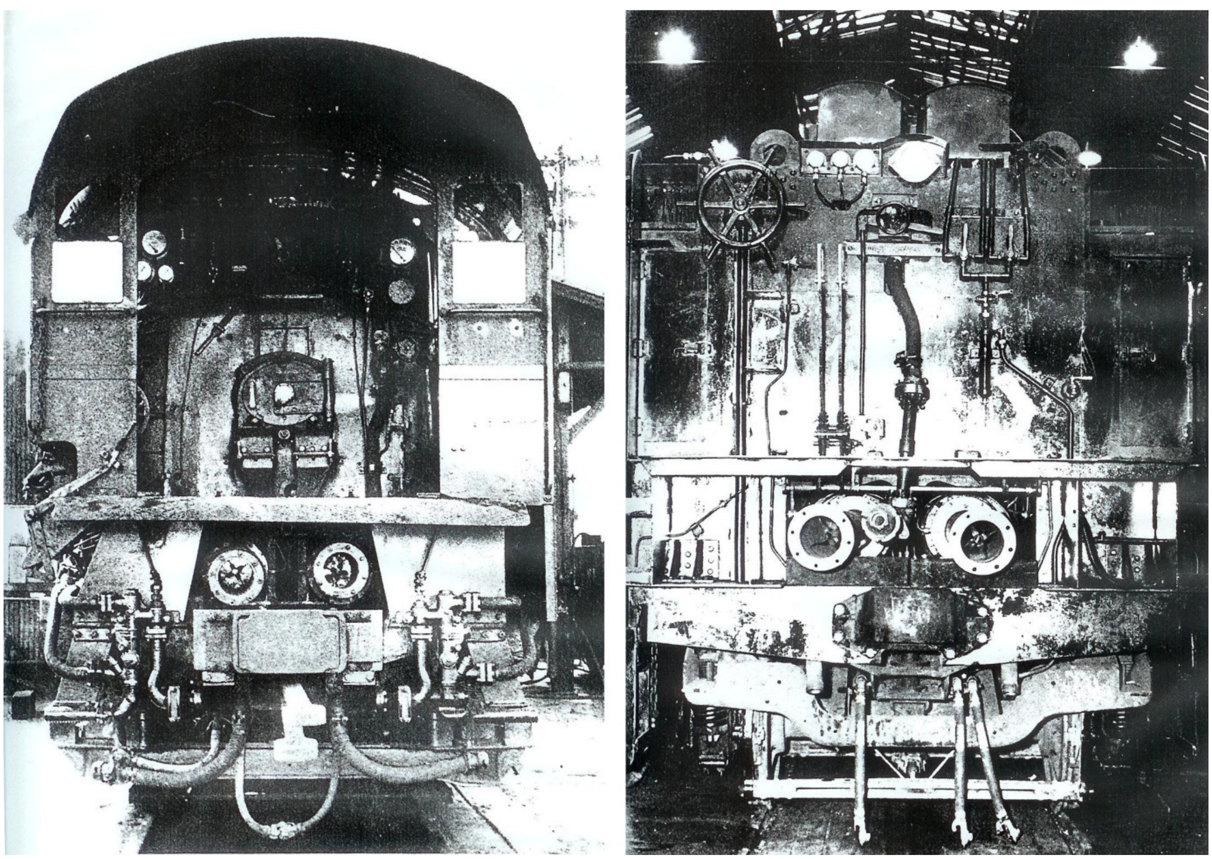
The fully enclosed coal hopper had three dust-tight filling hatches fitted with fuel strainers which tapered downwards to two longitudinal cast iron troughs in which were housed the coal conveyor screws. The fuel hopper had a capacity of nine tons (746 cubic feet) of PBC dust. However, due to the area occupied by the transmission unit and primary air ducts the water tank capacity was reduced by 3,000 gallons to 6,000 gallons.

Due to the location of the turbine, blowers and feed screw drive at the rear of the tender the location of the water filling hole, normally placed centrally at the rear, had to be altered, with filling holes located instead on either side of the tender adjacent to the cab.

The weight of the tender fully laden was reduced by 4.7 tons to 75.1 tons, and the engine unit by 2 tons to 105.6 tons. The roadworthy weight of engine and tender was reduced to 180.7 tons, an overall saving of 6.7 tons.

The PBC hopper was fitted with compressed air turbulence jets, controllable from the cab, for use if arching of the coal over the conveyor screws took place. A fuel level indicator was provided on the tender front plate to indicate the level of the fuel in the hopper. A pressure gauge was also provided to show if pressure had built up within the hopper due to the operation of the turbulence pipes or for any other reason. In the event of a pressure build-up a release valve was provided.

- **Mechanical Equipment:**



Left: Backhead of boiler of R707 showing modified firehole door, turbine steam line and main stop valve and fuel-air mixing ducts under the cab floor which feed directly into the rear of the firebox. Right: Front plate of R707's tender as converted, showing control valves, gauges and the fuel-air mixing ducts

The combined drive dust firing system was driven by a single 24 bhp steam turbine which actuated the two primary air blower fans and the dust conveyor screws operating in the tunnels at the base of the fuel hopper. The turbine unit and the shaft-driven fans were mounted on top of the tender at the rear.

The two blower fans, which had a combined maximum output of 330,000 cubic ft of air per hour, blew air through throttle valves and ducts extending beneath the conveyor screw troughs to the mixing chambers where it met the coal being brought forward by the conveyor screws.

The fuel conveyor screws were driven by the turbine through a worm and wormwheel drive, vertical drive shaft, bevel wheels and a

transfer gearbox which divided the drive to the two separate screws. Between the transfer boy and the conveyor screw shafts were clutch mechanisms, operated by levers on the front of the tender, by means of which either, or both of the conveyor screws could be engaged or disengaged at will.

These conveyor screw operating levers were operated through quadrants having four notched positions. Movement from the first to the fourth notch positions progressively opened a throttle valve in the air duct which increased the amount of air supplied through the burners, thus purging the coal-air passages before engaging the conveyor screws.

Movement from the fourth to the fifth notch or vertical position, operated the clutch mechanism, engaged the conveyor screw and opened the sealing slide on the conveyor screw outlet.

An interlocking device was fitted between the conveyor screw operating levers and the turbine throttle valve which ensured that the turbine was running and that air was blowing through the fuel ducts both before the conveyor screws could he engaged and after they had been disengaged. This prevented any blockage of the fuel ducts with Coal dust.

Regulation of the steaming rate was by engagement of one or two conveyor screws as required, and the adjustment of the steam supply to the turbine to control the turbine speed, A revolution counter and turbine steam supply pressure gauge were provided on the tender front plate to indicate the speed of the turbine and to show any abnormality in the steam pressure required to attain this speed.

Flexibility of the coal-air mixture pipe between engine and tender was provided by telescopic pipes and ball joints. The ball joints on both engine and tender were lubricated through grease nipples situated on the firedoor secondary air ducts and the front plate of the tender.

The turbine had pressure feed lubrication to all bearings and an oil pressure gauge was provided on the front plate of the tender to indicate whether the lubrication system was functioning during running. An oil level gauge was also provided on the turbine sump and the level of oil had to be checked on this gauge before each trip, and at stops en route should any irregularity in oil pressure be detected.

The transfer gear box was splash lubricated from a deep sump and the oil level of the sump was indicated on an oil level gauge built into the casing.

Lubrication of the front conveyor screw bearings was by grease through nipples provided on the front plate of the tender. All other bearings were lubricated from oil boxes and trimmings situated on the back plate of the tender.

Operation

The conveyor screws fed dust from the hopper into the two tubular mixing ducts, which extended from in front of the screw housings to the burners in the firebox backplate via the flexible joints at the engine-tender connection. From the mixing chambers the coal-air mixture was propelled forward by the air velocity, through pipes fitted with whirling devices to the two burners located horizontally just beneath the foundation ring on either side of the longitudinal centre line of the boiler. Each burner plate was perforated by 1,320 nozzles, each with a 5.75 mm orifice, to facilitate ignition of the PBC within the firebox.

The combined maximum output of the two screws was 4,850 lb of coal per hour at the maximum turbine working speed of 4,200 revolutions per minute. With a single burner in operation fuel consumption could be regulated down to 750 lb per hour.

The turbine required from 1.5 per cent to 4 per cent of the total steam output for its operation depending on operating conditions of load and grade, and to a lesser extent, the weather conditions encountered en route.

Service Instructions

Departmental instructions for lighting up and operating PBC tired engines were comprehensive and this no doubt contributed to the good safety record enjoyed throughout the six years operation of X32 and two years for R707 as dust-burners during general pool operation out of North Melbourne Locomotive Depot.

Whilst no explosions were ever experienced extreme care had to be taken during refuelling, as the microscopically small particles of fuel would float in the air and combust more readily than petrol. Both engines were involved in a number of fires arising out of spillage of fuel which then ignited whet) other locomotive moved over the area where refuelling had occurred. X32 caught alight however when refuelling at Bendigo Locomotive Depot whilst under test with a trial shipment of specially prepared pulverised briquettes.

Lighting up from cold using the turbine and burners required a separate source of steam to drive the turbine and tile creation of an artificial draught in tile smokebox. Alternatively, the engine was able to lie lit up with a wood lire, as for a grate-tired engine, using small flood and waste. A pressure of 50-90 psi of steam had to be raised before changing over to PBC firing. When the fire had ignited the turbine speed was regulated to about 1,500 rpm to exhaust fumes from the firebox.

One burner at this rate was normally all that was required to raise full pressure and take charge of light engine demands until the engine was ready to leave with the train. In the event that the engine had full steam and water before the train was due away tile conveyor screw could be disengaged and the operating lever left in the fourth notch position for a few minutes to blow the ducts through with air, then moved to tile first notch position. Where it was known that there was to be no steam demand for a short period the turbine was shut down by applying the operating lever interlocking device, shutting the turbine throttle valve on tile tender and closing the blower. The damper was also to be closed to exclude cold air from the fire-pan.

Under service conditions the train was started with full steam pressure and one burner engaged. The second burner was not engaged until sufficient steam was being exhausted from the engine to create the draught necessary to clear the gases from tile firebox.

When using one burner however, the speed of the turbine was not to exceed 2,500 rpm. Consequently, to increase the steaming rate above this level, both burners had to be engaged and the turbine speed reduced or increased to give the desired steaming rate.

The best guide to proper combustion under all conditions of firing was the colour of the chimney exhaust. There was to be no more than a light haze of smoke in the exhaust even at the maximum steaming rate. Smoke from tile exhaust indicated that either insufficient air or too much fuel was being fed to the firebox, resulting in incomplete combustion, poor steaming and fumes in the cab.

Over undulating country of light gradients the proper method of firing was to use one burner continuously, allowing the boiler pressure to fall slightly on the rises and build up again on the rolling sections rather than be continuously engaging and disengaging both burners. In this way the firebox was not subjected to fluctuations in temperature which could cause leaky tubes.

On long rolling sections the equipment was to be shut down completely and the dampers closed after boiler pressure and boiler water level built up to a satisfactory level. If the turbine and blower fans were left running, even at a low speed, with the burners disengaged, they would blow cold air into the firebox and set up undue strain on the firebox plates and tubes.

In order to reduce the build-up of slag formations on the firebox tubeplate dry sand was introduced into the firebox through the inspection hole in the firedoor every twenty to thirty miles when steaming heavily so that the draught carried the sand with tile maximum velocity to knock the formations clear.

These slag build-ups were also experienced in the 1923-24 Fuller-Lehigh brown coal tests and christened ‘swallow's nests’ because of their appearance. They were formed due to the fine PBC ash melting in the intense heat of the firebox and ‘freezing’ onto the relatively cold tube plate and superheater tubes.

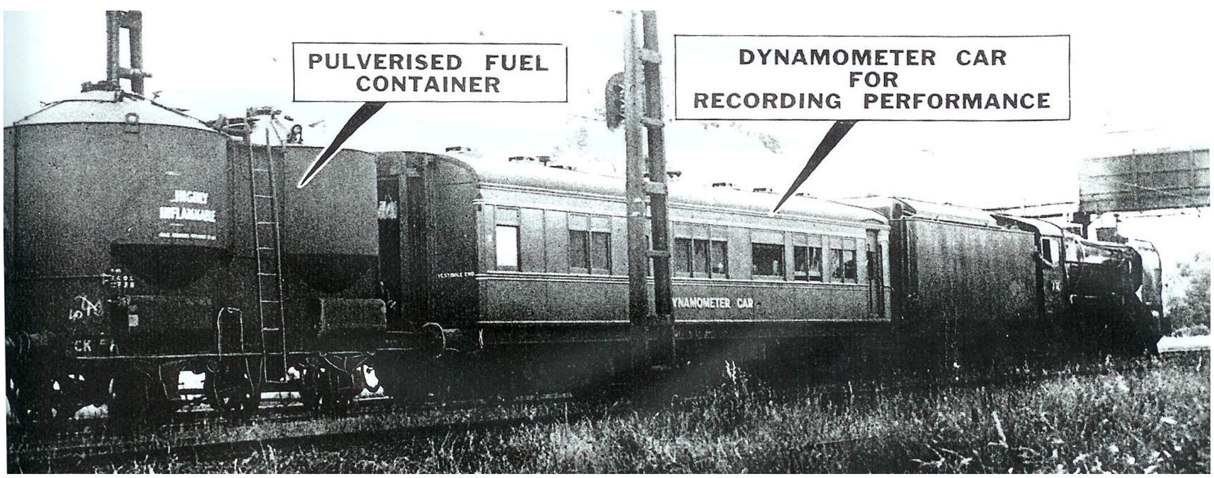
It was subsequently found that both engines required regular cleaning of tube plates and at times the removal of some superheater elements to clear ash deposit blockages.

Fuel Handling and Storage

The precipitator dust used by the engines was loaded by the State Electricity Commission at Yallourn into special-purpose four wheel wagons of the 'CK' class for transport to the fuelling point at North Melbourne Locomotive Depot. The design of these vehicles was based on wagons widely used in Germany for the transport of pulverised brown coal for commercial use.

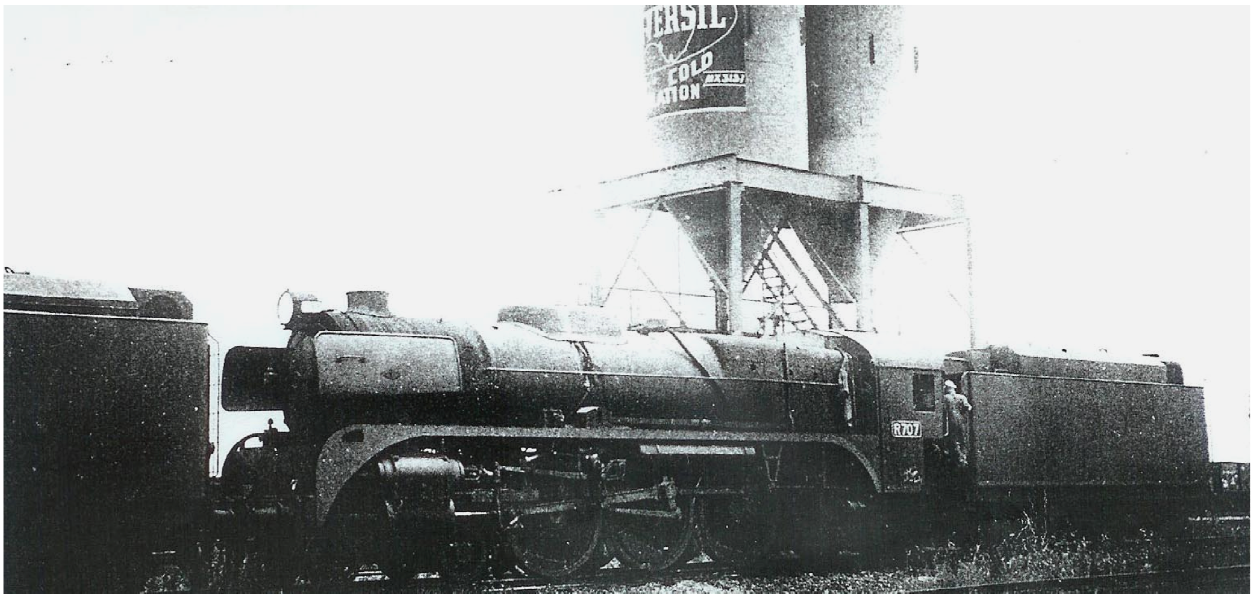
The 'CK' wagons had a tare weight of nearly 12.5 tons and held approximately 14 tons of Yallourn precipitator dust in two separate sealed containers. They were equipped for top filling and bottom discharge and were coned at the bottom to ensure complete discharge of all the dust at each emptying.

At Yallourn the dust was transferred from the briquette factory to the rail loading point (about 300 ft distant) and loaded into the wagons with the aid of a Fuller-Kinyon pump. Filter bags were fitted to the supply line to permit dust-free air to be exhausted from the container during the filling operation. When this was completed the containers were sealed and remained so until discharged. Each container was also initially fitted with CO_2 fire-fighting equipment as a precaution against spontaneous combustion. The firefighting equipment was later discarded as tests showed that ignition would not occur while the containers were sealed and if a fire started during refuelling resealing the lids would quickly extinguish the flames.



A Herald-Sun Feature Service photo depicts X32 on a down Bendigo gods departing Sunshine with the dynamometer car and a CK wagon of PBC dust, 9th November 1949 [ARHS Archives]

The engines were refuelled at North Melbourne Locomotive Depot directly from 'CK' wagons with the aid of compressed air either from the engine itself or from a depot supply line. When the compressed air was obtained from the main reservoir of the locomotive it was fed to the wagon through a drier/pressure-reducing unit. This regulated the air supply to the 30 lb per square inch pressure limit of the wagon containers. The filling hose was then connected from the wagon outlet to the centre filling connection of the locomotive bunker. Filter bags were also fitted to the connections provided for the purpose in the two end hatch covers. On opening the outlet valve of the wagon, container dust flowed into the bunker at a rate of about a ton per minute. In practice however filling of the engine bunker took between 30 and 60 minutes, although this would have been reduced to about 10 to 15 minutes using the overhead bunkers at North Melbourne Depot. The PBC dust hoppers were in fact erected at the depot in 1953 but never commissioned due to the decision of the State Government not to allocate loan funds for the conversion of further locomotives to PBC dust firing.



R707 Stabled at North Melbourne Locomotive Depot. In the background may be seen the PBC dust storage bunkers which were never to be commissioned or brought into use, circa 1955. [STATE TRANSPORT AUTHORITY]

R707 in Service

During the design-development stage of the conversion of R707 to PBC firing, the Rolling Stock Branch expressed concern as to the margin in water capacity likely to be available under service conditions on Bendigo passenger train schedules. Water consumption tests (Table 24) were accordingly conducted with a number of black coal-burning R class shedded at North Melbourne Locomotive Depot in the period 10th to 17th March 1952.

Table 24
Water Consumption Tests
Melbourne-Bendigo Section - 1952

Date	Train	Engine	Loads in Tons	Consumption	Remarks
10.3.52	1.30 pm down	R708	6/200	6,800	Includes 500 gal. account shunting Bendigo pass yard and RH injector wasting water
13.3.52	12.30 pm up	R708	7/275	5,640	-
11.3.52	12.30 pm up	R713	8/310	4,930	-
12.3.52	1.30 pm down	R713	5/180	5,450	Includes 400 gal. account shunting Bendigo pass. yard.
14.3.52	1.30 pm down	R705	6/205	5,450	Consumption measured at Bendigo station. Engine did not go over pit until 5.30 pm after shunting Bendigo pass. yard.
17.3.52	1.30 pm down	R705	6/220	5,300	Dipped at Bendigo Station.

The Chief Foreman at North Melbourne was requested to arrange for the tanks of the R class scheduled to run the 1.30 pm down and the 12.20 pm up passenger trains oil alternative days dipped and total consumption recorded. The tests showed consumption to range between 4,930 and 6,800 gallons, depot to depot. They were to have a profound influence on the engines' utilisation when issued to traffic in late 1954.

Just prior to completion of the conversion of the engine in June 1954, it was decided to remove the special turbine blower wheels and conveyor screw bevel gears installed on X32 which was then undergoing a boiler examination at North Melbourne and refit them to R707. (X32 was subsequently refitted with the blower wheels and conveyor components which had been supplied originally by Henschel and Sohn in 1948.) Prior to its issue to traffic the Rolling Stock Branch proposed that the engine be rostered for two Melbourne-Geelong trips each day, 300 days per year, subject to a 66% availability factor. As the aggregate mileage thus calculated (35,600) was uncertain, due to experimentation requirements and the encroachment of diesel-electrics on the passenger service, an annual mileage of 33,000 at a firing rate of 80 lb per mile was adopted.

This compared more than favourably with that experienced with X32 which was then burning approximately 123 lb per mile for an annual mileage of some 34,000. The easier firing rate estimated for R707 was however largely because the major part of its work was to be on passenger trains of light average loadings. Total annual requirement for PBC dust was therefore estimated at 1,880 tons for X32 and 1,180 for R707, approximately 3,000 tons per annum.

One Monday to Saturday proposal showed R707 scheduled to run the Melbourne-Geelong leg of No. 90 fast (News) goods to Warrnambool which departed Melbourne at 1.20 am, returning on No. 20, a proposed 6.10 am up ex-Geelong (this train was to appear finally as a Saturdays only 7.17 am 280 hp railcar service ex-Werribee). The engine was then to be turned and fuelled preparatory to running No. 47 stopping passenger, departing at 12.33 pm for Geelong. It was then to return on The Flyer, No. 56 up Melbourne passenger which departed Geelong at 5.08 pm and ran the forty-five miles to Spencer Street in 57 minutes, which included the last seven miles in from Newport through the Melbourne suburban area at a maximum speed of 40 mph. The planned utilisation of the engine never materialised however as by the time R707 entered service in August 1954 diesel rosters had made significant inroads into passenger services previously handled by the R class.

Prior to issue to traffic the engine was subjected to static steaming trials at North Melbourne as soon as sufficient supplies of PBC were available. Once these were completed and adjustments made to the locomotive, R707 was rostered to run a number of road tests on the Bendigo main line during October 1954 with Driver A. Hall and Fireman J. Bodsworth at the controls.

The first two tests, Nos. 1953 and 1954, were conducted between milepost 12½ and Bendigo on the 18th October 1954 and Bendigo to Woodend the following day. The test engineer's report showed that with an equivalent blast pipe diameter of 6.05 in, modified blowers, a goods load of 39/418 tons on the down and 25/420 tons on the up, the engine used 14,880 lb of Yallourn PBC dust having a calorific value of 10,330 Btu/lb and an ash content of 1.34%. Total water consumption was 9,182 gallons with actual evaporation of water at the rate of 6.17 lb per lb of precipitator dust. (See Table 25 for test details.)

Table 25 *Efficiency* Tests *with Dynamometer Car* *R707 PBC Firing: Melbourne-Bendigo Section - 1954*				
Power Test Numbers	**1953/54**	**1955/56**	**1957/58**	**Average**
TRAIN CONDITIONS				
Average load in tons	419	419	419	419
Running Test Section in minutes	258.5	247	263	256.2
Yard to Yard in minutes	467	439	424	443.3
Test Section ER and meals in minutes	14	23	18	18.3
AVERAGE STEAM CONDITIONS				
Boiler Pressure psi	205	204	205	205
Superheat Temp °F	695	690	691	692
PERFORMANCE: MELBOURNE - BENDIGO - MELBOURNE				
Water evaporated (lb)	116,870	100,180	107,850	108,300
Coal burned (lb)	18,640	-	16,412	-
Work units	1,866.45	-	1,770.3	-
Evaporation lb water/lb coal	6.26	-	7.04	-
Equiv. Evap. at 212°F lb water/lb coal	8.65	-	9.6	-
Work units per lb coal	0.1001	-	0.1078	-
Overall efficiency %	4.98	-	5.36	
PERFORMANCE: MILEPOST 12.5 - BENDIGO - WOODEND				
Water evaporated (lb)	91,820	80,880	90,850	87,850
Coal burned (lb)	14,880	13,120	13,602	13,867
Work units	1,591	1,277.97	1,528.3	1,465.76
Evaporation lb water/lb coal	6.17	6.16	6.66	6.33
Equiv. Evap. at 212°F lb water/lb coal	8.5	8.46	9.12	8.69
Work Units per lb coal	0.1070	0.0975	0.1122	0.1056
Overall efficiency %	5.33	4.85	5.58	5.25

The running time, milepost 121/2 to Bendigo, was 162 minutes net after allowing a total of 26 minutes for engine requirements, a meal break at Gisborne and 12 minutes of stops for test purposes en route. The return leg, Bendigo to Woodend, was run in 961/2 minutes net. Average boiler pressure and superheat temperature during the tests were 205 psi and 695°F respectively and the overall efficiency of R707 was calculated at 5.33%. Four further tests, Nos. 1955-58, were carried out over the following four days, 20th to 23rd October 1954, with similar results.

Following the tests under simulated goods train conditions a further two power tests were scheduled on 28th October 1954, using empty bogie passenger stock and the dynamometer car, for a total trailing load of 350 tons.

The Acting CME, G.F. Brown, issued a special circular for the run directing again that Driver A. Hall and Fireman J. Bodsworth were to be in charge and for the train to be run express at the maximum line speed then prevailing; the only stops on the down journey being ten minutes at milepost 12½ for test purposes and fifteen minutes at Gisborne for engine requirements. On the up run the train was scheduled to stop at Castlemaine fifteen minutes for engine requirements and Woodend five minutes for test purposes.

The 'S' circular issued for the run showed an overall running time of 190 minutes and a net of 160 minutes on the down and 170 minutes and 150 minutes respectively on the up with 137 minutes scheduled between milepost 12½ and Bendigo and 85 minutes between Bendigo and Woodend. However, on the day of the test R707 departed milepost 12½ at 10.05 am with a load of 352 tons comprising ten empty passenger cars and the dynamometer car, and despite the scheduled stop at Gisborne of eight minutes, arrived in Bendigo at 12.04 pm for an elapsed time of 111 minutes (Table 26) which represented a net gain of 26 minutes over the schedule.

Table *26*

Power Tests *Running Times*

R707 PBC Firing; Melbourne-Bendigo Section - 1954

	Scheduled Net Running Time	**Net Running Time**
Down	**Minutes**	**Minutes**
Mileage *12½*	0	0
Sydenham	5	4½
Diggers Rest	14	11
Sunbury	20	16
Clarkefield	33	27
Riddell	40	32
Gisborne	52 (20 mins ER and wait line clear)	39(8 mins ER and test purposes)
Macedon	58	44½
Woodend	66	52
Carlsruhe	71	56
Kyneton	76	60½
Redesdale Jnc.	80	64
Malmsbury	84	67½
Taradale	89	71
Elphinstone	92	74
Chewton	97	78½
Castlemaine	101	82½
Harcourt	109	89
Ravenswood	119	98
Kangaroo Flat	129	107
Golden Square	131	109
Bendigo	137	111
Up	**Minutes**	**Minutes**
Bendigo	00	00
Golden Square	4	4
Kangaroo Flat	7	7
Ravenswood	19	18
Harcourt	31	27½
Castlemaine	37 (15 mins engine requirements)	33
Chewton	44	39 (8 mins test purposes)
Elphinstone	54	50
Taradale	57	52½'
Malmsbury	63	57
Redesdale Jnc.	68	61
Kyneton	73	65
Carlsruhe	79	71 (6 mins test purposes)
Woodend	85	77

Average speed over the 88¼ mile test section was a creditable 47.6 mph which was 72% of the average line speed of 65.4 mph then prevailing over the test section. This performance was well above the general average line speed standards of the broad gauge system although the up 'Spirit of Progress' schedule of 220 minutes in the early 1950s did require an average speed of 52 mph or 74% of line speed, over the 191 miles from Albury.

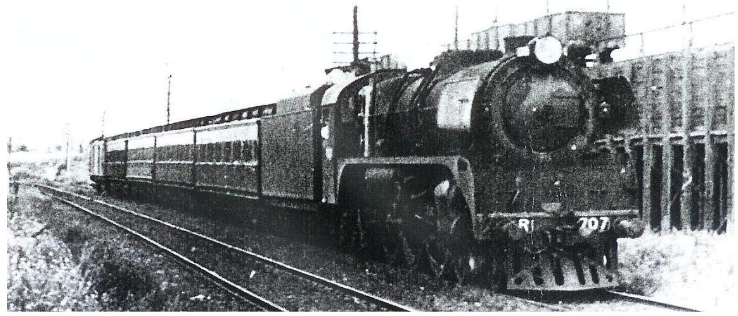
The test section was particularly severe for down trains as the first 34 miles climbed at an average grade of 1 in 112 to an altitude of 1902 ft above sea level at the crest of the Great Divide. Pulling away from milepost 12½, down trains faced an immediate climb up a 1 in 130 grade for nearly a mile followed by 1½ miles of 1 in 50 out of Jacksons Creek, Sunbury, the 4½ mile Riddell Bank at generally 1 in 56/57 (32 mph at 15 in cut-off - 1670 dbhp) and a further 5'/2 miles up the Macedon Bank which commenced at 1 in 69 for 1½ miles, then a short level easement followed by a mile of 1 in 96 through Macedon station, a descent of 1 in 99 for quarter of a mile followed immediately by a stiff climb at 1 in 52 for 2¼, miles to the crest of the Great Dividing Range.

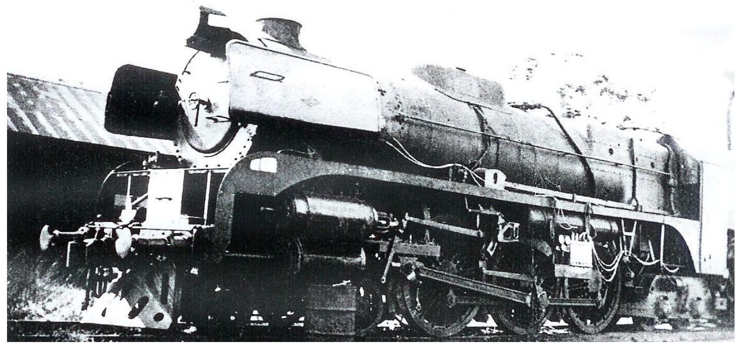
The remaining 54¼ miles were conducive to fast running as the line of railway gradually descended the northern slopes of the Great Dividing Range to Bendigo at an altitude of 758 ft. However, the three grades encountered en-route required the vigilance of both driver and fireman if the schedule was to be maintained. The first was the relatively easy 1½ mile climb to Elphinstone Tunnel commencing at 1 in 220 and steepening to 1 in 117 over the last mile followed by the 2½ mile pull out of Barkers Creek Valley on the down side of Harcourt at 1 in 55 which progressively eased to 1 in 79/122, and the shorter 1½ mile pinch of 1 in 50 up to the Big Hill Tunnel easing to 1 in 106 through the tunnel itself. The opportunity to take advantage of momentum grades was limited though as speed limits on the Bendigo main line were far more restrictive than they are now. Maximum speeds permitted from 3rd June 1953 for R class were as follows:

Milepost 121/4 to Sydenham: 50 mph
Sydenham to Woodend: 70 mph
Woodend to Carlsruhe: 60 mph
Carlsruhe to Taradale Viaduct at milepost 67: 70 mph
Taradale Viaduct at milepost 67 to Bendigo: 60 mph

The return test run departed Bendigo at 2.13 pm and, apart from an eight minute stop at Chewton and six minutes at Carlsruhe, R707 arrived Woodend at 3.44 pm for an elapsed time over the 52¼ mile test section of 77 minutes, which was a net gain of seven minutes on the schedule. The rather lower average speed of 41 mph by R707 was clearly influenced by the fact that over 38 miles of the run was limited to 60 mph, but it did represent 68.5% of the 60 mph speed limit which was a particularly good result considering the long and steep gradients encountered en route. The most notable of these being the eight mile south-bound climb to the northern portal of Big Hill Tunnel which steepened to 1 in 67/56 over the last four miles, the 4½ mile grade out of Ravenswood at 1 in 113/85/57 and the 6½ mile grind up Chewton Bank to Elphinstone Tunnel at 1 in 59/50 from a 25 mph permanent way restriction over Forest Creek on the up side of Castlemaine. The dynamometer car chart showed that at the entrance to the tunnel R707 was developing 1500 dbhp whilst holding 24.5 mph at 17 inch cut-off.

Having regard to the road tests of R707 through October 1954 and the water consumption tests conducted in early 1952 between Melbourne and Bendigo, it became clear that the engine had insufficient water capacity to run express passenger trains on the Bendigo main line and still have an adequate margin for inclement weather and delays in traffic. A further factor was that considerable costs would have also been incurred in establishing permanent fuel handling facilities at Bendigo. It therefore became obvious that the most economic utilisation of the engine would be out-and-back freight and passengers runs from Melbourne to Geelong and Seymour. In addition, given a maximum consumption of about 100 lb per mile of PBC dust, the Geelong and Seymour round trips, which entailed mileages of 95 and 132 miles respectively out-and-back to North Melbourne Depot, were comfortably within the 200 mile range of the engine's 746 cubic feet fuel bunker.





***Top** – A rare photo of R707 operating as a PBC dust-fired engine, seen here passing Geelong Loco Depot with an up passenger train, March 1955.*

***Bottom**- R707 undergoing stationary steaming trials at North Melbourne Loco Depot, 27th August 1954.*

Consequently, in view of the special fuel handling equipment already established at North Melbourne Locomotive Depot, the availability of specially trained crews, fitters and workshop facilities, both X32 and R707 were shedded at North during their service life as PBC dust-fired engines under the watchful eye of running shed fitters Harold Casley and Jack Lloyd.

The R707 story would not be complete without reference to the R class constructional defects for which NBL were liable. The VR refused to make the final 5% payment on R707, due on completion of 200 miles running test, and exercised the warranty provision in the contract that 2,000 train miles should apply in lieu. Whilst the defective welds on boiler stay sleeves, tender bogie centre plates and transoms had not become evident before 2,000 train miles had been completed by the sixty-nine locomotives then in service, the VR was of the view that the cost to rectify these and other faults on R707 should also be debited to NBL as the faults had delayed its entry into service.

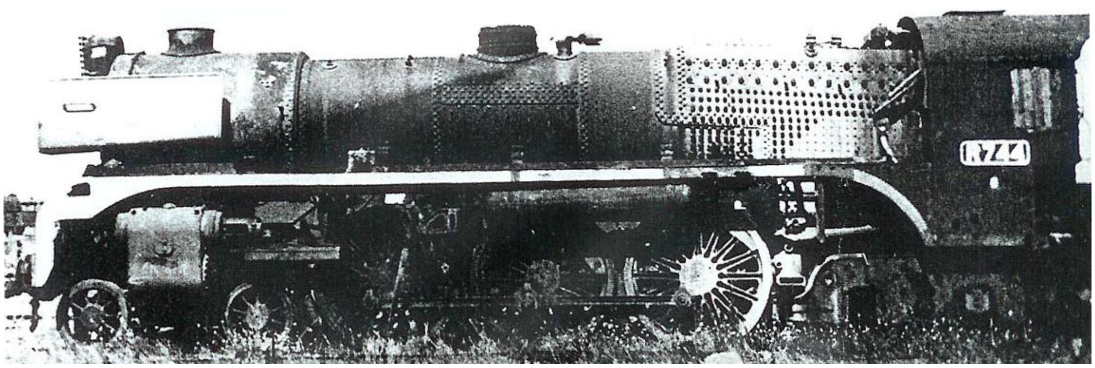
Consequently it was not until 15th November 1954, when R707 had completed 2,083 miles of service, including the test runs on the Bendigo line, that arrangements were put in hand for the final payment to NBL in connection with the manufacture, supply and delivery of the seventy R class locomotives.

As soon as regular supplies of PBC dust were available and sufficient crews trained in its operation R707 entered regular running. The engine was more often than not rostered on the 6.05 pm down Geelong passenger train from Spencer Street on weekdays, returning with the 9.40 pm up goods, conveying mainly bulk cement loading from the Fyansford cement works, the same evening.

Other workings of the locomotive included an occasional appearance on the up Geelong Flyer and an early morning down goods to Seymour, returning on the up Numurkah passenger train the same day.

Coincidently both PBC engines were taken out of traffic in May 1956; X32 because of service repairs and R707 after it came off the road and bent the leading coupled axle and damaged the flanges of the leading bogie. Directions were issued on 7th May 1956 for repairs to be effected at North Melbourne. However, with further additions to the diesel fleet it was subsequently decided to discontinue the PBC test program and X32 was set aside and scrapped in August 1957. As R707 had run only 30,761 miles in twenty-one months of service, the engine was stored pending instructions until 28th February 1957 when the CME directed that it be sent to Newport Workshops for conversion to black coal-firing.

The Assistant CME in a subsequent memo on 1st March 1957 called for the engine to be returned to traffic at the earliest. He directed that the pulverised fuel firing equipment (including the pulverised fuel tender and underframe) be removed from the engine and held pending further instructions. The Workshops Manager was also requested to install a tender and underframe from one of the black coal-fired R class engines held at Newport onto R707's tender bogies. Engine R744, which had been shopped some months earlier for heavy mechanical and boiler repairs, was cannabilised of fittings, cleating, lagging and the tender to facilitate the reconversion of R707.



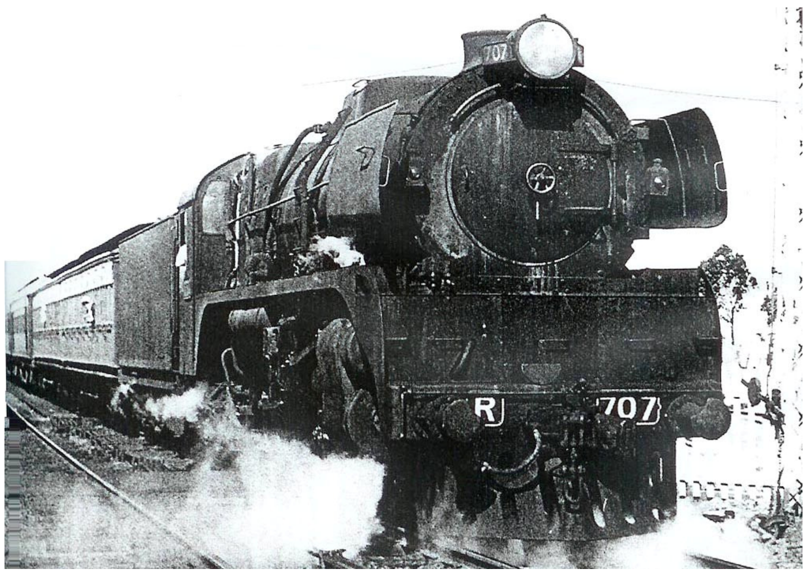
R744 in a semi-stripped condition at Newport Workshops, 18th Feb 1960

The engine's reissue to traffic on 31st May 1957 signalled the end of a unique technological experiment. The use of PBC dust was clearly a technical success with the very good combustion of the finely divided fuel offsetting its lower calorific value. However the combination of the progressive dieselisation of the locomotive fleet and the high labour and fuel costs experienced with the maintenance and running of the two engines made their continued operation uneconomic.

The epitaph to the PBC experiments was, in Chapman's words:

> If the escalating costs and periodic disruptions to the supply of NSW coal during the 1940s and 1950s had been paralleled by continued restrictions on the import of diesel technology, we would have had more PBC locomotives. They were however too late on the scene to be seriously considered as a viable form of motive power.

Steam's last opportunity to stem the inroads of diesel-electric traction on the Victorian Railways was gone.



Shortly after its issue to traffic as a coal-fired engine, R707 departs Sydenham with the down Daylesford passenger train, May 1957.

Post-script: Reproduction of this chapter from the book "Hudson Power" by Robert Carlisle and Bill Abbott is made available through the 5AT website with the kind permission of Robert Carlisle who owns the copyright of the book.

oo000oo