R E P O R T

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A S   A   F U E L

F O R

V I C T O R I A N   R A I L W A Y S   L O C O M O T I V E S

31st July, 1950.

REPORT

ON

PULVERISED BROWN COAL

AS A FUEL

FOR

VICTORIAN RAILWAYS LOCOMOTIVES

W. O. GALLETLY.

31st. July, 1950.

PULVERISED BROWN COAL LOCOMOTIVE 32 "X" UNDERGOING DYNAMOMETER CAR TRIALS

LOCATION :– MACEDON BANK – 1 IN 52 GRADIENT

LOAD :– 656 TONS

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REPORT ON PULVERISED BROWN COAL AS A FUEL FOR VICTORIAN RAILWAYS LOCOMOTIVES

SUMMARY OF REPORT

General

In 1949 the Victorian Railways commenced their second series of trials with pulverised brown coal fired locomotives.

The original tests were carried out in 1923-4 on 'A', 'C' and 'DD' classes fitted with "Fuller Lehigh" firing equipments. These gave promise of later success, if certain technical problems could be satisfactorily solved; but the cost of the fuel at that time was too high for economic operation.

The current series of trials are being conducted on locomotive 32 'X'. This class was selected because of its large firebox and combustion chamber which give the furnace volume and flame-length necessary for success in this method of firing.

The locomotive was equipped with the 'STUG' type of firing equipment, designed and manufactured by the German firm of Henschel and Son. Similar equipment was applied with success to two 'G-12' class locomotives of the German State Railways in 1931 and they continued in service at least until World War 11.

Details of the German experience with these locomotives and others equipped with different types of pulverised fuel firing equipments, together with their method of handling and storing pulverised brown coal, were studied by Mr. W.H. Chapman and myself during our visit to Germany in 1946. The knowledge gained was then applied to the conversion of locomotive 32 'X', to the design of the fuel transport wagons and to the tests that have been conducted to date.

Fuel Supplies

As was the case in Germany, the fuel used for our trials was the precipitator dust collected from the drier stacks of a briquetting factory - in our case from Yallourn.

This material is superior to that produced by the pulverisation of briquettes or briquette material, because of its lower moisture content - 6% as compared with 14% - and its resulting higher calorific value - 10,400 as compared with 9,500 B.T.U.

It has the disability however of being coarser than the accepted standard for locomotive firing, 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. This however did not prevent success in the trials.

Available information concerning the likely characteristics of precipitator dust from the new Morwell factories suggests that it may be regarded as the equivalent of Yallourn dust.

Transport Wagons and Storages

The pulverised brown coal was transported from Yallourn to the refuelling points at North Melbourne and Bendigo in special-purpose sealed wagons of the 'CK' class. These have a contents load of about 14 tons with a tare of 12 1/2 tons and their design is based on that of vehicles widely used in Germany for the transport of pulverised brown coal for commercial uses.

SUMMARY OF REPORT

Transport Wagons and Storages (Contd.)

These wagons have bottom outlets and are discharged with the aid of compressed air. In the case of our tests they were also used as storage containers and the locomotive was fuelled directly from them.

This method of refuelling however is too slow for practical purposes and plans are in hand to design and erect two prototype overhead hoppers of 56 tons capacity each. There will be patterned on German experience and should enable locomotives to be refuelled in about 10 minutes.

Locomotive Trials

Comparative Standing and Dynamometer Car trials were conducted on the converted locomotive - 32 'X' and an equivalent grate fired unit - 30 'X' - burning various classes of lump black coal.

From these the following general knowledge was gained:-

(a) The pulverised brown coal fired locomotive developed more power than its grate fired equivalent burning Wonthaggi, Lithgow or even Maitland coal.

(b) It operated on goods services without difficulty with the same loads as the grate-fired unit and showed a reduction in the running time possible with either Lithgow or Wonthaggi coals.

(c) It also showed a reduction in E.R. times, because the cleaning of fires at Intermediate and terminal points was eliminated.

(d) Although the calorific value of the pulverised brown coal is lower than that of any of the black coals tested, the fuel consumption of the converted engine was less than that of the grate-fired unit, except when it was fired with Maitland coal. The improvement was due to a higher boiler efficiency.

The evaluations of pulverised brown coal to the black coals, as determined by the trials were:-

1.15 tons pulverised brown coal = 1 ton Maitland coal.

0.96 " " " " = 1 ton Lithgow coal.

0.93 " " " " = 1 ton Wonthaggi coal.

(e) The steam requirements of the turbine driving the pulverised brown coal firing equipment, varies from 1 1/2 to 4% of the boiler output, depending on the steaming rate. This is more than offset, however, by the additional water used by the grate fired engine - when burning Wonthaggi or Lithgow coals - as a result of intermediate fire-cleaning and slower running.

(f) Pulverised brown coal firing also has the following advantages:-

Elimination of manual firing,
Elimination of spark arrester cleaning,
Elimination of spark hazard,
Elimination of smoke nuisance,
Improved cab conditions generally.

SUMMARY OF REPORT

Locomotive Trials (Contd.)

(g) The only apparent problem still to be solved concerns the efficient handling and storage of the pulverised fuel and the rapid refuelling of locomotives. Research of this nature is now in hand.

Spontaneous combustion

In the course of our trials, extending so far over nearly 12 months, no case of spontaneous combustion of pulverised brown coal has occurred during its transport or storage, except when artificially created. Tests have shown that this fuel can be stored with safety in sealed hoppers, for at least one month and probably indefinitely.

Explosion hazard

Our experience to date suggests that, with our design of equipment and reasonable care on the part of operators, there is little to fear from the explosion hazard that is normally associated with the use of this fuel.

Nevertheless it must be kept in mind that pulverised brown coal is highly inflammable when mixed with the proper proportion of air and that care will always be necessary in its handling and storage.

This should principally be a matter of equipment design, however, and education of the staff concerned.

Research in hand

Following on the recent agreement by the State Electricity Commission to increase our supply of pulverised brown coal to 28 tons per day as soon as facilities can be made available, the Commissioners approved of the following works being carried out:-

(a) The conversion of a new 'N' class locomotive, using the second equipment purchased from Germany,

(b) The construction of an additional 5 'CK' wagons - This will bring our total up to 7,

(c) The erection of two 56 ton overhead fuel storage hoppers, one at North Melbourne and one at Yallourn.

It is hoped to complete these works by abour July 1951 - when the State Electricity Commission expect to be in a position to make the increased fuel supplies available. Our two converted locomotives then will operate on an extended service trial on the Melbourne-Yallourn service.

SUMMARY OF REPORT

Economic Survey

Availability of pulverised brown coal

A high quality pulverised brown coal, suitable for locomotive firing, is collected in precipitators installed in the drier stacks of briquetting factories, at a rate approximating 7 - 10% of the total briquette output. It normally is utilized in the manufacture of briquettes; but could be collected and loaded into departmental transport wagons without great difficulty, with a corresponding reduction in briquette output.

This material has been considered as the basis for this survey. It has a higher calorific value than dust prepared by the mechanical pulverisation of briquettes or briquette material, as its moisture content is lower. Its cost should also be less as the pulverising process is eliminated.

The quantities of precipitator dust likely to be collected with the progressive expansion of briquette factories in the Latrobe Valley Area are:-

Stage of expansion	Anticipated quantity of precipitator dust collected. (tons per year)	
	7% basis	10% basis
1950 - Yallourn	38,000	54,000
1953-4 - Morwell No.1	83,000	118,000
1954-5 - Morwell No.2	135,000	193,000
1956-7 - Morwell No.3	183,000	262,000
1958-9 - Morwell No.4	232,000	331,000

Locomotives suitable for conversion and fuel demand

The principal requirement of the pulverised brown coal locomotive is a large firebox, which should embody a combustion chamber to give flame-length. This is provided in our 'H', 'S', 'X', 'R' and 'N' classes and they would be suitable for this form of firing.

The 'H' and 'S' classes have been disregarded because of the small numbers involved and the survey has been confined to the other groups which would require the following amounts of fuel:-

Group	Requirements of pulverised brown coal. (tons per year)
44 'X' class (29 extg. - 15 new)	83,000
70 'R' " (new)	97,000
100 'N' " (30 extg. - 70 new)	97,000
Total: 214 locomotives	277,000

SUMMARY OF REPORT

Economic survey (Contd.)

The combined demand of these three groups therefore could not be met until the Morwell No.4 Factory is in operation - anticipated about 1958-9 - but the following progressive conversions would coincide with the anticipated availability of fuel. The resultant savings in black coal are also shown:-

Year	Conversions coinciding with antic., fuel availability (7% basis)	Total black coal saved (Tons per year)
1953-4	44 'X'	83,000
1956-7	70 'R'	176,000
1958-9	50 'N'	224,000
1959	50 'N'	273,000

The second 50 'N' class conversions could only be undertaken if an 8-1/2% dust collection figure applied.

Locomotive conversion costs

The nett costs involved in converting these classes of locomotives, assuming that the work is done in conjunction with major repairs at our workshops, are £8,200 each for the 'X' and 'R' classes and £7,600 for the 'N' class. These are based on a local quotation of £5,000 for the manufacture of the equipments.

Basic fuel costs

Pulverised brown coal

In the absence of precise information, the following basic rates are assumed for the pulverised brown coal:-

From Yallourn Briquetting Factory - 30/- per ton f.o.r. Yallourn.

" Morwell " " - 37/6 " " f.o.r. Morwell.

Black coal

The future supply position for this fuel is indefinite. It appears however that the Department will have to import large quantities of black coal for some years, unless substitutes are found for it and that, within reasonable limits, the conversion of locomotives to burn brown coal will obviate the need to import an equivalent quantity of black coal. Accordingly the following black coal rates have been used for the economic survey:-

Group		Class of coal and rate per ton
44 'X' class	:	Principally imported @ £6.7.0 f.o.r. Melbourne.
70 'R' class	:	South African @ £6.9.4 f.o.r. Melbourne.
100 'N' class	:	Lithgow @ 63/6 f.o.r. Wodonga. 66/- f.o.r. Tocumwal.

SUMMARY OF REPORT

Economic survey (Contd.)

The actual landed costs of the imported coals have been used in order to obtain the true position from a State or National viewpoint.

To show the effect on Railway finances, however, under the conditions now applying to the payment of a Government subsidy on all overseas coal, figures have also been computed using the current New South Wales parity rate of £3.13.8 paid by the Victorian Railways.

The subsidy applying to this coal now averages about £2.13.4 per ton.

Added fuel charges

To the basic fuel rates must be added the following amounts in order to arrive at an equitable cost of each coal as loaded into locomotive bunkers:-

Black coal

A transport charge of 1.33 pence per contents ton-mile.

A handling and storage charge of 2/4 per ton for mechanical and 4/3 per ton for manual plants.

Pulverised brown coal

An increased transport charge of 2.34 pence per contents ton-mile. This provides for the special purpose nature of the wagons and the empty back haulage involved.

A handling and storage charge of 3/6 to 4/- per ton. This provides for overhead storage hoppers wherever necessary to enable locomotives to be rapidly refuelled and for a central emergency briquette storage and pulverising plant as an insurance against possible dislocations in the supply of precipitated dust.

Anticipated annual savings of pulverised brown coal locomotives

The estimated annual savings - based on the foregoing factors - that would result from the conversion of the three groups of locomotives to pulverised brown coal firing are shown below. The total expenditure that would be involved in each case, including the provision of transport wagons, over-head hoppers and the emergency briquette storage and pulverising plant are also indicated:-

Group	Estimated consumption of pulverised brown coal	Anticipated annual savings (all charges)		Estimated expenditure involved in conversions (1)
	(tons per year)	National viewpoint (£)	V.R. viewpoint (£)	(£)
44-X	83,000	227,600	+ 30,100	881,000
70-R	97,000	224,800	- 34,000	1,278,000
100-N	97,000	8,500	+ 8,500	1,474,000
214	277,000	460,900	+ 4,600	3,633,000

Note (1). These estimates are based on the assumption that the rolling stock programs would be carried out in Departmental shops.

SUMMARY OF REPORT

Economic survey (Contd.)

From the National viewpoint, the conversion of these 214 locomotives should therefore show an annual saving of £460,900 after all charges have been deducted.

Under prevailing conditions, this saving would be practically offset by the Government subsidy for the imported coal involved and therefore little financial gain to the Department would result from the conversions unless the subsidy were removed in the meantime.

On the other hand, they would incur no Departmental loss, even after all the associated charges were met and should provide a sound insurance against future disruptions in train services arising from poor fuel or inadequate supplies.

For these reasons and also because of the other advantages associated with pulverised brown coal firing that cannot be given a definite monetary value, the conversion of these three groups of locomotives is considered a desirable and a worthwhile proposition.

Lines to be operated by the proposed pulverised brown coal locomotives

Appendix 8 shows the lines that would be operated by the three groups of locomotives included in the economic survey and the refuelling points applying to each.

This assumes:-

(a) Prior electrification of the Melbourne-Traralgon and Melbourne-Geelong lines.

(b) That 'R' class locomotives will be permitted to run on all lines now authorised for the "A2" class and,

(c) That 'N' class locomotives will be restricted to lines with turning facilities suitable for them.

RECOMMENDATIONS ARISING FROM REPORT

In view of the foregoing and having due regard to the desirability of making this Department particularly and the State generally, much less dependent on coal supplied from outside the State, it is recommended:-

(1) That the State Electricity Commission be asked:-

(a) To confirm the within estimates concerning the progressive quantities of precipitated dust likely to be collected in their briquetting factories,

(b) For an assurance that this could all be made available to this Department for the firing of locomotives,

(c) For an indication as to the earliest dates that they will be in a position to make sufficient dust available for the initial conversions - i.e. 58,000 tons a year for the 29 existing 'X' class locomotives and 25,000 tons a year for the 15 'X' class locomotives now on order.

(d) For any additional data they may be able to supply concerning the likely characteristics of the Morwell Factory precipitator dust, e.g. moisture content, fineness, analysis and ash fusion temperature.

(2) That the conversion to pulverised brown coal firing of the existing 28 black coal burning 'X' class locomotives then be undertaken so that the group would be available for operation on this fuel as soon as the State Electricity Commission are in a position to make supplies available.

(3) That the 15 'X' class locomotives ordered on the Clyde Engineering Works be constructed as pulverised brown coal locomotives, providing that no undue delay in delivery is thereby incurred and that the delivery date would approximately coincide with the availability of pulverised fuel for them.

(4) That all the works - as listed on Tabulation 3 Appendix 5 - associated with the conversion and operation of the above two groups of locomotives on pulverised brown coal, be provided concurrently with the conversion of the locomotives, at a total estimated cost of £881,000.

(5) That one 'R' class locomotive be converted as a prototype at the same time as the 'X' class conversions - approval has already been given for the application of the second firing equipment purchased from Germany to a prototype 'N' class.

This action would enable some experience to be gained with the operation of 'N' and 'R' class locomotives on pulverised brown coal prior to undertaking large scale conversions.

(6) That, providing the prototype tests are successful, the 70 'R' and 100 'N' class groups then be converted as soon as fuel supplies can be made available, at a total estimated cost, including associated works, of £2,752,000.

REPORT ON PULVERISED BROWN COAL AS A FUEL FOR VICTORIAN RAILWAYS LOCOMOTIVES

INTRODUCTION

1923-24 Tests

The Victorian Railways' interest in brown coal as a locomotive fuel dates back to 1921 when the State Cabinet authorised the Commissioners of the Victorian Railways and the State Electricity Commission of Victoria to conjointly proceed with experiments in the utilization of pulverised brown coal from Yallourn in locomotive boilers. The State Electricity Commission was then responsible for the production and supply of the pulverised brown coal and the Railway Department for the locomotive experiments. These trials were conducted during 1923-4 and the results are contained in Bulletin No.1 (1926) "The Newport Experimental Drying and Pulverising Plant for the Treatment of Brown Coal" of the State Electricity Commission.

For these trials locomotives 800 'A2' (saturated) 16 'C' (superheated) and 1022 'DD' (superheated) were fitted with American "Fuller Lehigh" firing equipments and their performances were compared with those of grate-fired engines of the same classes using Maitland coal for the passenger train trials and Wonthaggi coal for those conducted on goods trains. The pulverised brown coal was obtained from a Fuller-Lehigh pulverising plant installed at the Newport 'A' Power Station and had approximately the following characteristics:-

Calorific Value	9,600	B.T.U. per lb.
Moisture	11	%
Volatile Matter	40	%
Fixed Carbon	42	%
Ash	6	%
Fineness	80	% through sieve of 200 meshes per inch.

The Maitland coal had a calorific value of 13,100 - 13,400 and the Wonthaggi coal 11,800 - 12,000 B.T.U.'s per lb.

These tests gave promise that at a later date pulverised brown coal might be successfully and economically employed in ordinary locomotive service; but at the time the cost of the fuel was too high for economic operation. Moreover the reliability of the equipment was only fair, while undue noise was created by the auxiliary engines in the cab and trouble was experienced with ash deposits on the tube plate.

The amount of water used by the pulverised brown coal locomotives as compared with their grate fired equivalents was found to be excessive, the increases being about 22% for the 'DD' class, 18% for the 'A2' class and 6% for the 'C' class. Their fuel consumptions as compared with black coal firing, were also high, as shown below:-

'DD' class	-	61% increase on both the Maitland and Wonthaggi coal figures.
'A2' class	-	31% increase on Wonthaggi coal figure.
		64% increase on Maitland coal figure.
'C' class	-	18% increase on Wonthaggi coal figure.

Introduction (Contd.)

From the results of these trials it was determined that in competition with Victorian black coal costing 22/5 per ton at Wonthaggi and Maitland costing 34/3 per ton at North Melbourne, the economic value of 350 tons per day of pulverised brown coal, when used on the main Gippsland line and at North Melbourne, Woodend, Bendigo and Seymour, was 17/9 per ton f.o.r. Yallourn, less the charges applying to the extra cost of the special trucks required for its handling and the reduced reliability of the locomotives arising from the added equipment.

German Investigations

The next development occurred in 1937 when, as a result of the knowledge that the German State Railways had successfully operated a small group of experiemental pulverised brown coal fired locomotives for a few years, this Department corresponded with the firm of Borsig Locomotive Works of Berlin regarding the suitability of the German firing equipment for adaptation to our 'N' class locomotives.

In 1939 these negotiations were terminated by the outbreak of war. In view of the advantages of the German equipment over any others available and the difficulties that would be encountered in attempting to develop suitable equipment locally, the Commissioners then decided to pend further tests until German equipments could be obtained or details of the German design could be made available for local manufacture.

Accordingly in 1946 Mr. W.H. Chapman and myself went to Germany to make a detailed study of their methods and to arrange for the purchase of one or two sets of equipments for further trials. The results of these investigations are contained in our report "German Locomotive Experience with Pulverised Fuels and Lump Black Coal". (B.I.O.S. Final Report No.765).

On our return the Commissioners authorised that an 'X' class 2-8-2 goods locomotive be fitted with one of the two sets of the pulverised brown coal firing equipments ordered on the German firm of Henschel and Son and that it be tested in competition with a comparable grate-fired engine burning various classes of local lump black coals.

The results of these trials and associated investigations form the subject of this report.

CONVERSION OF 2-8-2 GOODS LOCOMOTIVE 32 'X'

Physical characteristics

Appendix 1 shows the physical characteristics of locomotive 32 'X', which was selected as the initial conversion to pulverised brown coal firing and of grate-fired locomotive 30 'X', which was chosen for comparative trials with various classes of lump black coals.

'X' class locomotives were preferred for these trials because their large fireboxes, with combustion chambers and thermic syphons, are suited to pulverised fuel firing, which needs ample furnace volume and long flame length. Cooling surfaces in the flame path, as provided by the thermic syphons, lower the gas temperature and thus reduce ash deposits on the tube plate.

The proportions of 'X' class all-steel boilers more or less apply to modern boilers likely to be considered by this Department for main-line engines and therefore the results achieved with 32 'X' should be reproduced without difficulty on them.

Both trial engines - 32 'X' and 30 'X' - were built in 1929 and were given a "thorough" overhaul in 1949. Each had allotted to it a replacement four year old all-steel boiler that had just undergone a first re-tubing. Thus, for all practical purposes the two engines can be regarded as similar. Their diagrams are shown in figure 1.

Details of the firing equipment of 32 'X' and its application

The pulverised brown coal firing equipment applied to locomotive 32 'X' is the "STUG" combined drive unit. This was designed and manufactured by the German firm of locomotive builders - Henschel and Son of Kassel - and had previously been applied by the German State Railways to two of their 2-10-0 "G-12" class goods locomotives in 1930-1. Figure 2 shows diagrammatically the method of applying the unit to locomotive 32 'X'.

In the course of this conversion the grate and ash-pan were removed and a firebrick-lined fire-pan was provided. The brick-arch was replaced by one of greater length and reduced angle, two "Stug" burners were installed in the back-plate of the fire-pan below the foundation ring and a fixed firedoor with a mica-covered peep-hole was fitted. The firebox arrangement is shown in figure 3.

The tender was completely reconstructed on the original underframe and bogies. The sealed coal-dust container has a capacity of 766 cubic feet or approximately 10 tons 4 cwts of pulverised brown coal dust and tapers downwards to two troughs which house the feed-screws. These supply the fuel to two burners which may be operated either together or independently with a combined maximum output of 4,850 lbs. of Yallourn brown coal dust per hour. With single burner operation supply can be regulated down to a minimum of 750 lbs. per hour and the equipment operates satisfactorily and efficiently over this range.

A 24 horse-power steam turbine, mounted on the rear of the tender so that its noise will not inconvenience the crew, jointly drives the two feed-screws and two fans which supply primary air to the burners. The fans have a combined output of 330,000 cubic feet per hour at about 12" w.g. pressure.

CONVERSION OF LOCOMOTIVE 32 'X'

Details of firing equipment (Contd.)

Only about 45% of the total air is supplied as primary air. The remainder is provided as secondary air at the following locations:-

Underneath the brick-arch	-	about 40%
Around the fire-door	-	" 5%
Through the fire-pan floor	-	" 10%

At least 50 lbs. per square inch steam pressure is required to drive the turbine and initially this is obtained either in the normal manner by a lighting-up wood fire or by tapping an auxiliary steam supply. Ignition of the fuel from the wood fire or from a piece of oily waste then presents no difficulty.

Full details of the lighting-up procedure are given in direction R.S.49/9376.

An important safety feature of the equipment is the interlock between the turbine steam supply valve and the clutch levers of the fuel screws. This ensures a good flow of air through the ducts before and after the burners are in use and prevents accumulation of dust in the ducts or fire-pan.

Figure 4 shows two views of the converted locomotive and figure 5 illustrates the location of its special controls, etc.

ENGINE

Cylinders (2) 22"d x 28"
Tractive Effort (85%) 39 360 lb
Tractive Effort with booster 48 360 "
Factor of Adhesion 4·28
Factor of Adhesion with booster 4 40

VALVE GEAR

Walschaert
Piston Valves 10" dia
Travel 4⅞" Lap 1⅛"
Lead ¼"

BOILER

Work. Press. 205 lb per sq in
Grate Area 42 sq ft
Heating Surface Sq Ft
Firebox & CC 199
Syphon 52
Tubes & Flues 2364
Superheater 492
3107

TENDER

Fuel 9 Tons.
Water 8600 Galls.

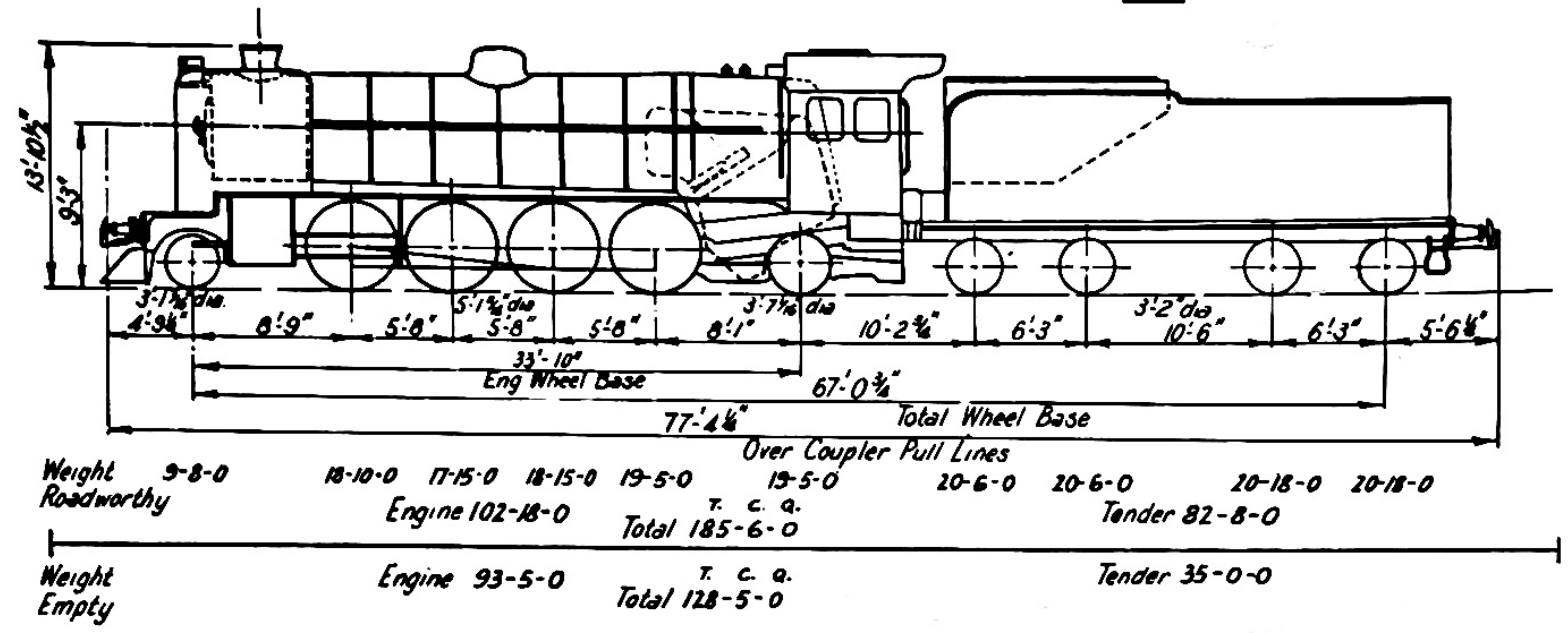


DIAGRAM OF GRATE FIRED LOCOMOTIVE-"30X" (AND "32X" BEFORE CONVERSION)

ENGINE

Cylinders (2) 22"d x 28"
Tractive Effort (85%) 39 360 lb
Tractive Effort with booster 48,360 "
Factor of Adhesion 4·28
Factor of Adhesion with booster 4 40

VALVE GEAR

Walschaert
Piston Valves 10" dia
Travel 4⅞" Lap 1⅛"
Lead ¼"

BOILER

Work. Press. 205 lb per sq in
Grate Area 42 sq ft
Heating Surface Sq Ft
Firebox & CC 199
Syphon 52
Tubes & Flues 2364
Superheater 492
3107

TENDER

P.V. Brown Coal {10-6-0 / 766 5 c ft
Water 6600 Galls

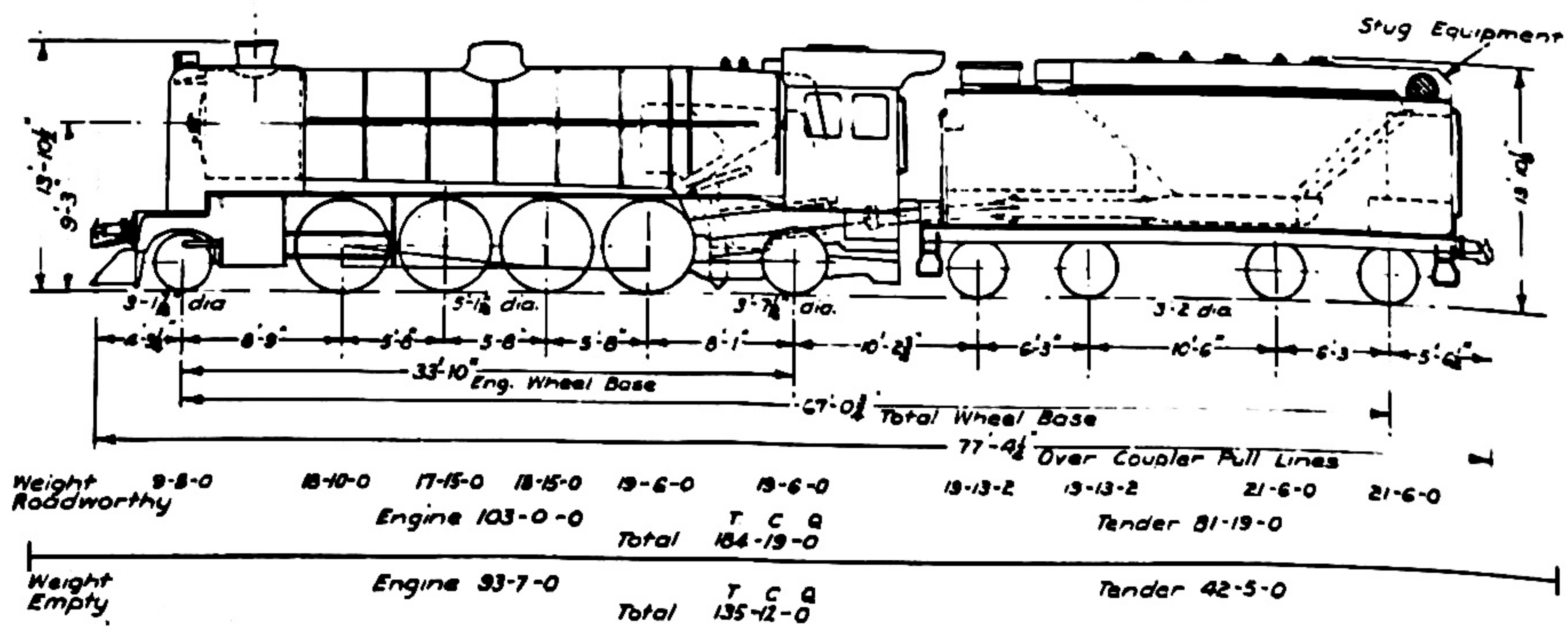


DIAGRAM OF P.B.C. LOCOMOTIVE -"32 X"

FIGURE 1

FIGURE 2. APPLICATION OF 'STUG' PULVERISED BROWN COAL FIRING EQUIPMENT

TO LOCOMOTIVE 32"X"

FIGURE 3. FIREBOX ARRANGEMENT

P.B.C. LOCOMOTIVE 32"X"

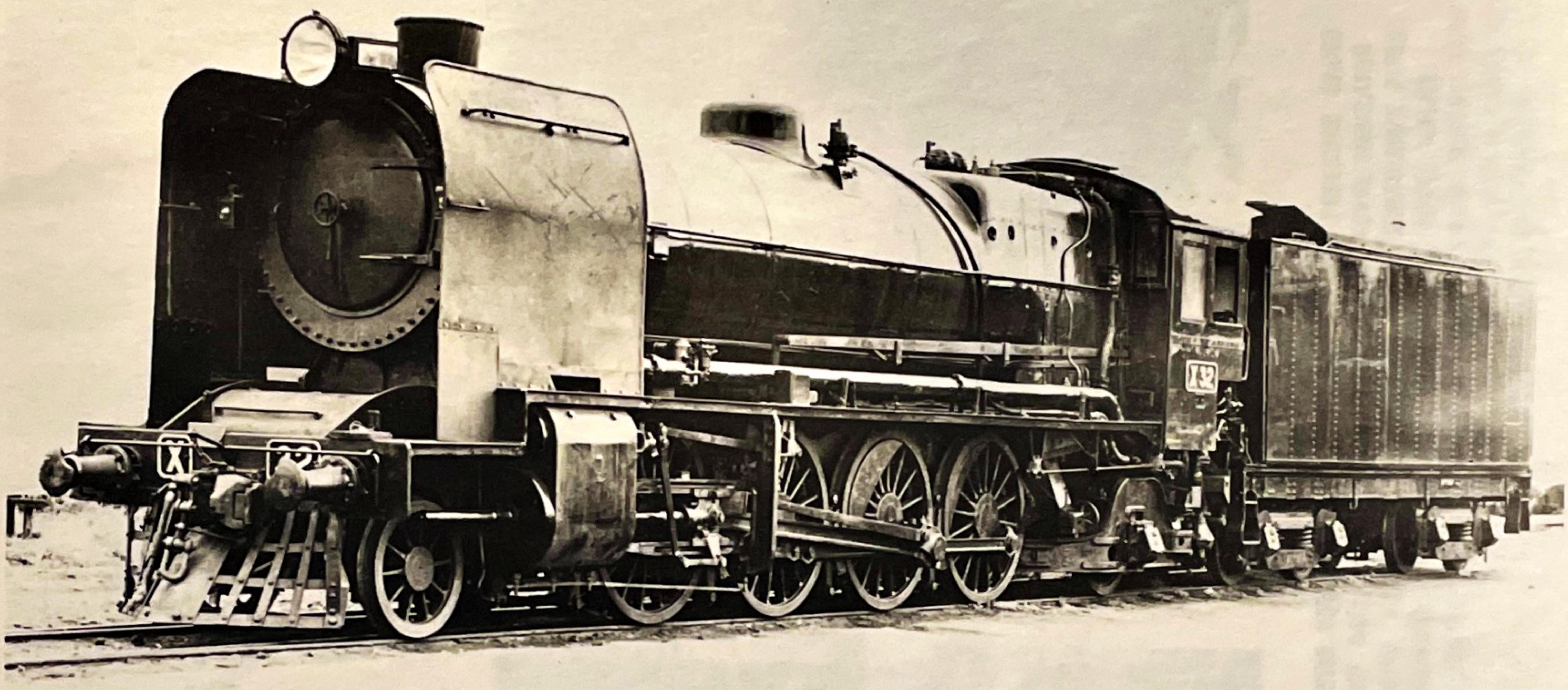
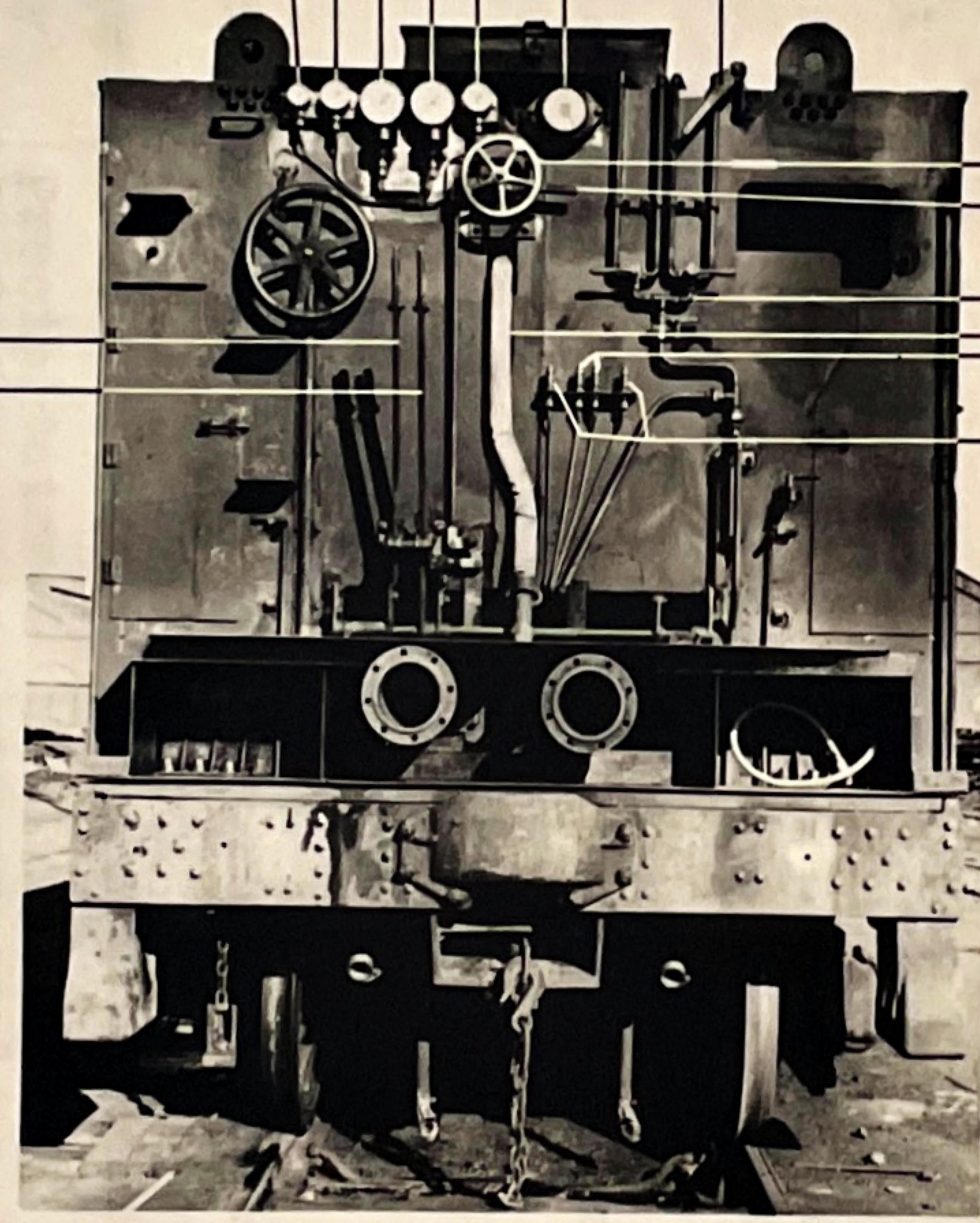


FIGURE 4. FRONT & REAR VIEWS OF CONVERTED LOCO. "32 X"

X 32 PULVERISED BROWN COAL FIRED LOCOMOTIVE
THE LOCATION OF CONTROLS ETC.



1 STEAM STOP VALVE
2 " REGULATING VALVE
3 SECONDARY AIR DAMPER CONTROL
4 FIRE DOOR
5 " " INSPECTION DOOR
6 " " CLAMPS
7 GREASE NIPPLES - BURNER DUCT BALL JOINT
8 AIR DUCTS TO FIRE DOOR
9 BURNER INSPECTION COVERS R & L.H.
10 TURBINE THROTTLE VALVE
11 INTERLOCKING LEVER
12 MAIN STEAM PIPE TO TURBINE
13 R.H. CONVEYOR SCREW OPERATING LEVER
14 L.H. " " " "
15 GREASE NIPPLES - FRONT CONVEYOR SCREW BEARING
16 " " BURNER DUCT BALL JOINTS
17 TURBINE STEAM PRESSURE GAUGE
18 " REVOLUTION COUNTER
19 " OIL PRESSURE GAUGE
20 FUEL BUNKER " "
21 R.H. AIR DUCT " "
22 L.H. AIR DUCT PRESSURE GAUGE
23 FUEL BUNKER LEVEL INDICATOR
24 " " TURBULENCE PIPES
25 TURBINE OIL LEVEL GAUGE
26 AUXILIARY STEAM CONTROL VALVE
27 OIL BOXES SCREW GEARS ETC.
28 GEAR BOX OIL GAUGE

FIGURE 5.

FUEL SUPPLY AND CHARACTERISTICS

Source of Supply

The pulverised brown coal used for these trials was supplied by the State Electricity Commission of Victoria. It was collected by them from electrical precipitators installed in drier stacks at the Yallourn Briquetting Factory.

It is understood that the quantity of dust collected in this manner represents about 7-10% by weight of the briquette output of the factory and at present amounts to about 50,000 tons a year. All this material is normally used for briquette production, however, and every ton sold as pulverised fuel would result in a corresponding reduction in briquette output.

By 1953-4 (when the initial Morwell Factory should be in operation) this quantity would increase to 80-120,000 tons a year and by 1954-5 should reach 140-190,000 tons, annually. The latter quantity would meet the requirements of 100-120 converted locomotives.

Characteristics: Proximate and Sieve Analyses

Typical characteristics of the Yallourn precipitator dust are set out in the following tabulations. Comparative figures for the pulverised brown coal used in the 1923-4 Victorian tests and by the German State Railways on their converted locomotives are also shown. The German material was also collected from Briquette Factories:-

PROXIMATE ANALYSES

	Victorian		German
Source of Supply	Precipitator dust - Yallourn Briquetting Factory (1949-50 tests)	Pulverised brown coal briquettes ex Yallourn (1923-4 tests)	Precipitator dust - Halle Area Briquetting Factory
Fixed carbon (%)	46.0	42.0	34.8
Volatiles (%)	46.0	41.0	42.1
Moisture (%)	6.2	11.0	13.3
Ash (%)	1.8	6.0	9.8
Calorific Value - gross(B.T.U/lb.)	10,450	9,600	9,340

FUEL SUPPLY AND CHARACTERISTICS

Characteristics (Contd.)

SIEVE ANALYSES

	Victorian		German
Sieve No.	Precipitator dust - Yallourn Factory (1949-50 tests)	Pulverised brown coal briquettes ex Yallourn (1923-4 tests)	Precipitator dust - Halle Area Briquetting Factory
Retained on B.S.S.No.36 (%)	1.1		The German State Railways Specification stipulated a residue of not more than 1% on B.S.mesh No.72 and not more than 20% on B.S.mesh No.170.
Retained on B.S.S.No.60 (%)	10.9		
Retained on B.S.S.No.100(%)		2.5	
Retained on B.S.S.No.120(%)	26.1		
Retained on B.S.S.No.150(%)	4.9		
Retained on B.S.S.No.200(%)		12.5	
Passing Thro'B.S.S.No.200(%)		85.0	
Retained on B.S.S.No.240(%)	30.3		
Retained on B.S.S.No.300(%)	4.1		
Passing Thro'B.S.S.No.300(%)	22.6		

Figure 6 shows graphically the size comparison of the three fuels included in the above tabulation.

Ash fusion temperature

The following figures for Yallourn brown coal ash were supplied by the State Electricity Commission and represent the averages of a series of tests in accordance with B.S.I. No.1016-1942:-

Initial deformation temperature

Reducing atmosphere - average not less than 2460°F.

Oxidising atmosphere- average greater than 2730°F.

Fusion temperature

Reducing atmosphere - average not less than 2550°F.

Oxidising atmosphere- average greater than 2730°F.

FUEL SUPPLY AND CHARACTERISTICS

Ash fusion temperature (Contd.)

As firebox temperatures of 2500°F. and over are experienced in a locomotive under service conditions, this characteristic of the fuel is of importance as it determines largely the degree of tube blockage that will occur due to molten ash formations known as "swallow's nests".

In the case of the German trials the ash-fusion temperature of the brown coal dusts used was generally under 1300°C. (2370°F.) and appreciable trouble was experienced by them with these tube-plate deposits.

Density

If brown coal dust is loaded into wagons or bunkers by means of compressed air, its density in the resultant aerated condition is lower than that which applies when the material becomes compacted in the course of transport. The following figures are typical for the Yallourn material under the conditions indicated:-

Condition	Density (lbs./c.ft.)
As loaded into 'CK' transport wagons at Yallourn by means of Fuller-Kinyon air-pump	30
As received at Melbourne in 'CK' transport wagons	38
As loaded into locomotive bunker by compressed air, from 'CK' transport wagons	30

Morwell Coal

Obviously it will not be possible to obtain details of precipitator dust from the Morwell Factories until they are in operation; but the following data published by the 'State Electricity Commission' maybe used as a basis for comparing it with the Yallourn material:-

Proximate analysis of coal dried at 105°C.

	Yallourn coal	Morwell coal
Volatiles	52.36	49.18
Fixed carbon	45.70	47.67
Ash	1.86	3.15
Calorific value (B.T.U.)	11,126	11,511

It is expected that the Morwell precipitator dust may be somewhat finer than the Yallourn material, that is moisture content may be a little higher and that the quantity collected may be a little less than 10% of the briquette output.

The increased ash content of the Morwell dust should be offset by its improved fineness and any increase in its moisture content above the Yallourn dust standard, should be balanced by its higher basic calorific value. Therefore for the purpose of this survey and until more precise information is available, it will be assumed that the two fuels are approximately equivalent and that an all-round collection of 7-10% will be possible.

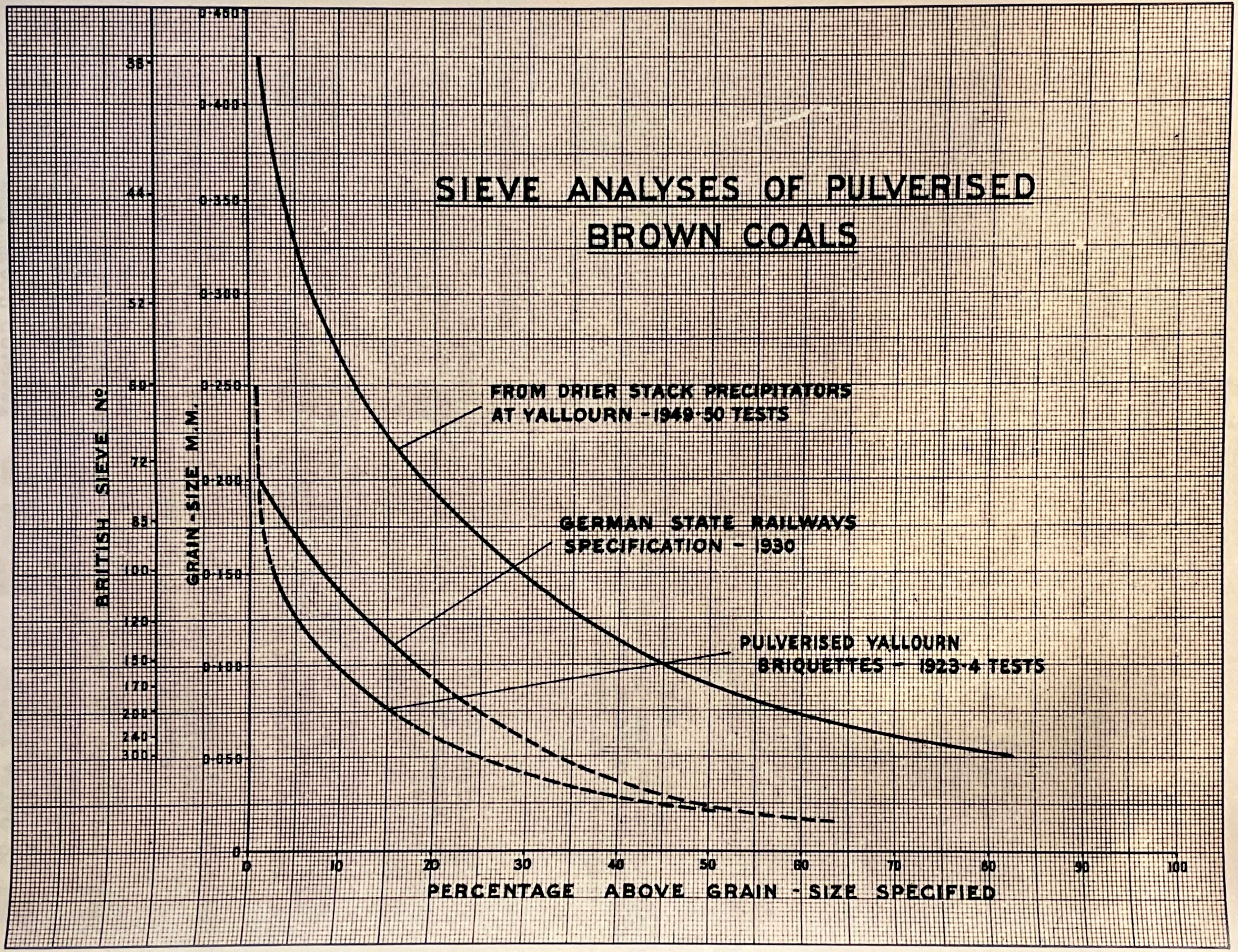

SIEVE ANALYSES OF PULVERISED BROWN COALS
FROM DRIER STACK PRECIPITATORS AT YALLOURN - 1949-50 TESTS
GERMAN STATE RAILWAYS SPECIFICATION - 1930
PULVERISED YALLOURN BRIQUETTES - 1923-4 TESTS
BRITISH SIEVE No
GRAIN-SIZE M.M.
PERCENTAGE ABOVE GRAIN - SIZE SPECIFIED
0
10
20
30
40
50
60
70
80
90
100

FIGURE 6

FUEL HANDLING AND STORAGE

Transport

The precipitator dust used for the tests was loaded by the State Electricity Commission at Yallourn into special purpose wagons of the 'CK' class for transport to fuelling points at North Melbourne and Bendigo. Figure 7 indicates the principal dimensions of these wagons and figure 8 the controls involved in their filling and discharge.

The design of these vehicles is based on wagons widely used in Germany for the transport of pulverised brown coal for commercial use.

The 'CK' wagons have a tare of nearly 12 1/2 tons and hold approximately 14 tons of Yallourn precipitator dust in two separate sealed containers. These are equipped for top filling and bottom discharge and are coned at the bottom to ensure complete discharge of all the dust at each emptying.

At Yallourn the dust was transferred from the briquetting factory to the rail loading point-about 300 feet distant-and loaded into the wagons with the aid of a Fuller-Kinyon pump. The supply line was attached to connection 9 (fig.8) and the filter bags were fitted to connection 3 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 is fitted with CO_2 fire-fighting equipment (item 11, fig.8) as a precaution against spontaneous combustion; but over approximately a twelve months test period it has not been necessary to use this equipment in the course of fuel transport.

Locomotive fuelling

The locomotive was fuelled at the North Melbourne and Bendigo Locomotive Depots directly from 'CK' wagons with the aid of compressed air - either from the engine itself or from a shop supply line - in the manner indicated in figure 9.

In the case shown the compressed air was obtained from the main reservoir of the locomotive and fed to the wagon through a drier - pressure reducing unit. This controls the air supply to the 30 lbs. per square inch pressure limit of the wagon containers.

Full instructions covering the operation of refuelling the locomotive in this manner are given in Instruction R.S.49/9377. Briefly the procedure is as follows:-

> The wagon container is pressurised up to the allowable limit and the filling hose is connected from the wagon outlet to the center filling connection of the locomotive bunker. Filter bags are then fitted to the connections provided for the purpose in the two end hatch covers. On opening the outlet valve of the wagon container dust flows into the bunker at a rate of about a ton per minute.

FUEL HANDLING AND STORAGE

Locomotive fuelling (Contd.)

Because of an inadequate compressed air supply at the North Melbourne and Bendigo Depots, however, the overall time involved in the refuelling operation was about 1 hour made up as follows:-

Pressurising container, connecting filler hose, attaching filter bags, etc.,	30 mins.
Transferring 7 tons of fuel from wagon to bunker,	10 mins.
Disconnecting hose and filter bags, sealing bunker hatches and stowing equipment.	20 mins.

Whilst this method of fuelling met the requirements of the tests, it must be regarded only in the nature of an expedient however and would be unsuited to service conditions that demand completion of the operation within 10 minutes.

To enable this to be done it would be necessary to instal an overhead bunker at each refuelling point. The wagons then would be discharged into this by compressed air in the manner already described and locomotives would be fuelled from it by gravity, through a telescopic chute that makes a sealed connection on to a locomotive filling hatch.

This principle is employed by German briquetting factories, for the storage of brown coal dust and the filling of transport wagons and is illustrated in figure 12.

Storage

Tests were conducted to determine:-

(a) How long Yallourn precipitator dust could be safely stored in bunkers,

(b) What combination of conditions was necessary to induce spontaneous combustion and,

(c) What is the best method to combat spontaneous combustion when it occurs.

For these tests one container of each 'CK' wagon (nos. 1 & 2) was loaded with brown coal dust at Yallourn and a continuous record was kept of the temperature of the dust at various levels. To simulate the conditions that would apply in service with hopper storage, the dust was transferred by means of compressed air from one container of each wagon to the other after arrival at the North Melbourne Locomotive Depot and with an allowance of a few days for likely transportation delays. The hatches then were resealed. It was thought that this introduction of fresh air to the coal may aggravate any tendency to spontaneous combustion.

Several weeks of storage under these conditions gave confidence that the dust could be safely stored in this manner for an indefinite period, so it was then decided to artificially create conditions favouring spontaneous combustion by introducing a continuous supply of fresh air to the surface of the dust by slightly raising the hatch cover and leaving it in that position.

FUEL HANDLING AND STORAGE

Storage (Contd.)

From the results of these tests and the German experience in the storage of brown coal dust the following conclusions are reached concerning the best type of overhead storage hopper for this fuel, its maximum storage period and certain other precautions that should be observed:-

1. The German Briquette Factory practice of using multiple overhead hoppers with gravity discharge for filling transport wagons could be satisfactorily applied to the fuelling of locomotives. In our case, however, the overhead hoppers would be filled from 'CK' wagons by means of compressed air, whereas in Germany the hoppers are loaded directly from the Briquetting Factory precipitators. A typical German layout of overhead multiple hoppers is shown in figure 12.

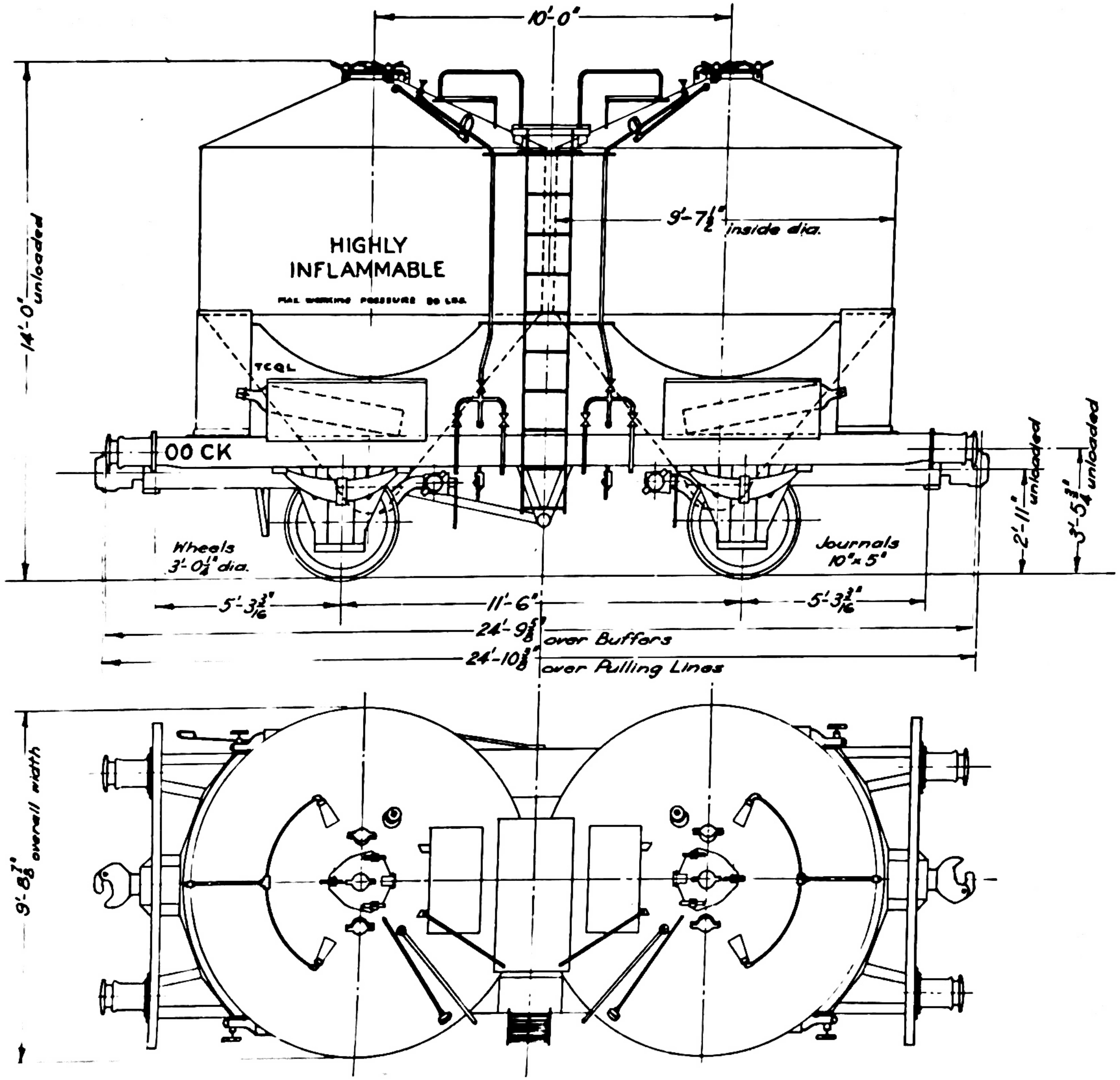
2. The capacity of individual hoppers should not exceed 28 tons, which equals the load of two 'CK' wagons. After filling, each hopper should be sealed until all the coal in it is used and no fresh fuel should be added until the hopper is completely emptied.

3. The maximum storage period for brown coal dust in any individual hopper should be limited to two weeks.

4. Each hopper should be washed out every two months.

5. In the event of a large scale conversion of locomotives to this form of firing it would be necessary to establish an emergency stock of briquettes at a central depot to guard against any serious dislocation in the supply of the brown coal dust. This stock would need to be in the order of four weeks requirements to give a reasonable insurance and the briquettes could be pulverised at a plant installed at the depot and distributed from there to other refuelling points by means of 'CK' wagons.

The economics set out in a later Section of this report allow for all these provisions.



GEN. ARRGT.	DRG. CK 1
CAPACITY	1032 CUB. FT.
TARE	12 T. 7 C. 3 Q. 0
MAX. WEIGHT ON RAIL	31 TONS
BRAKE CYLINDER	8" DIA. × 12"
BRAKE % - AIR	50·6 %
" " - HAND	21·3 %
PULVERISED BROWN COAL CAPACITY	14 TONS

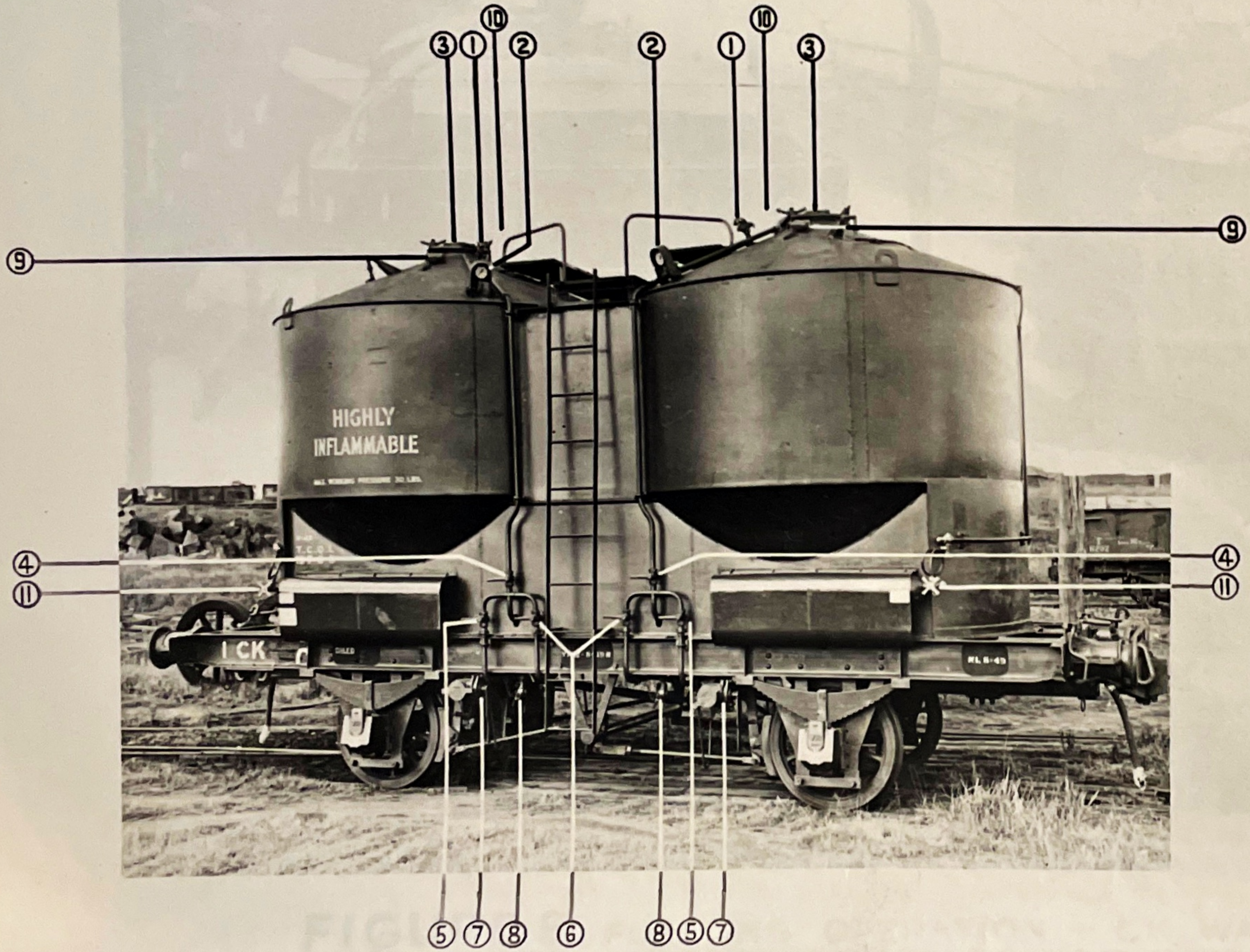
FIGURE 7

VICTORIAN RAILWAYS

WAGON CLASS **CK**

COAL DUST CONTAINER

'CK' CLASS PULVERISED BROWN COAL TRANSPORT WAGGON
LOCATION OF CONTROLS ETC.



1. AIR EXHAUST COCK.
2. PRESSURE GAUGE.
3. MANHOLE COVER WITH SCREWED FILLER CAP.
4. PRESSURE REGULATING COCK.
5. AGITATOR AIR CONTROL COCK.
6. DISCHARGE CONTROL COCKS.
7. COAL DUST DISCHARGE VALVE.
8. WESTINGHOUSE TYPE AIR COUPLING.
9. SCREWED CONNECTORS FOR FILTER BAGS.
10. SAFETY VALVE (ON OPP. SIDE OF CONTAINER).
11. CO_2 FIRE FIGHTING EQUIPMENT.

FIGURE 8

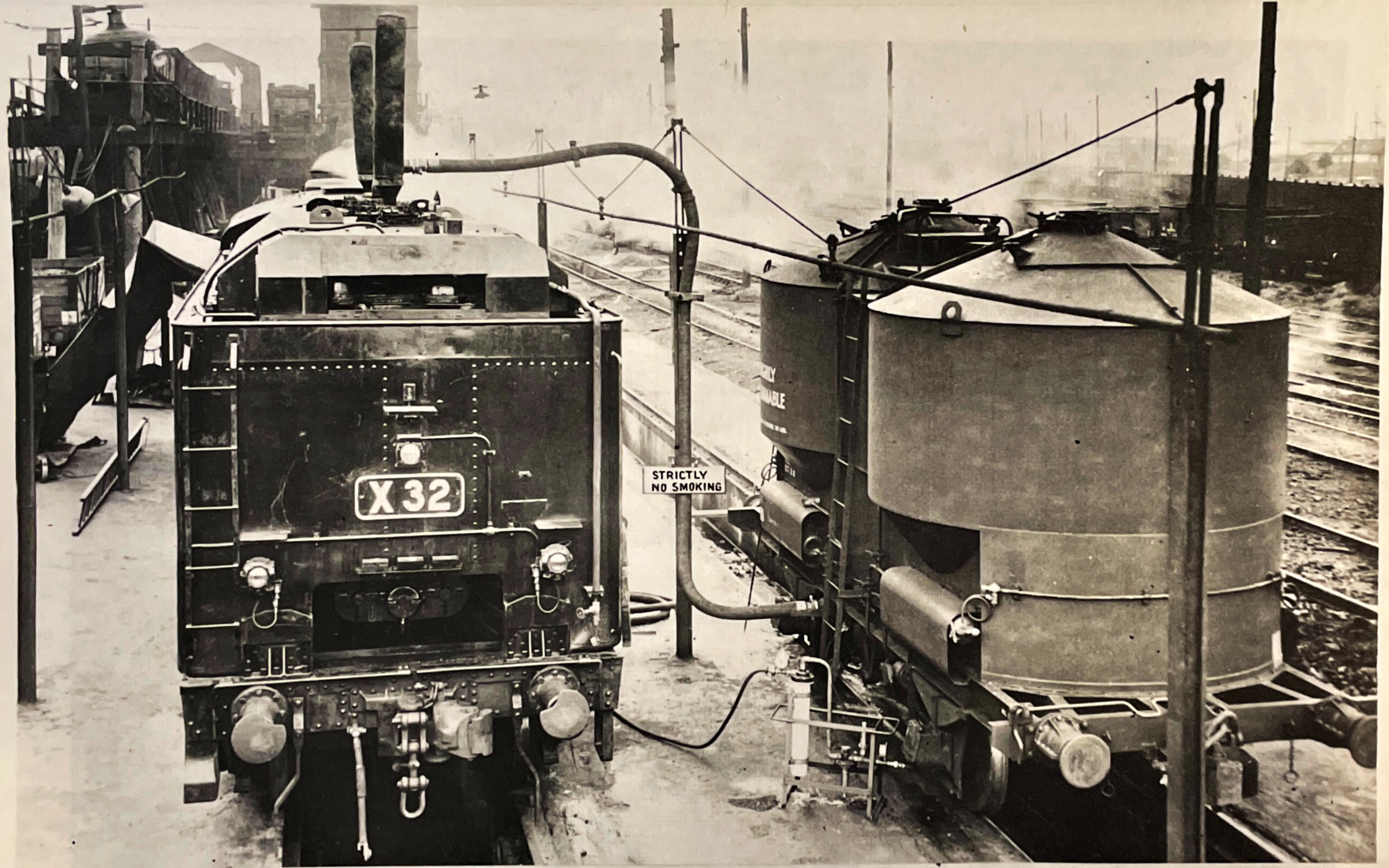


FIGURE 9. FUELLING OPERATION – C^{K} WAGON TO LOCO. "32 X"

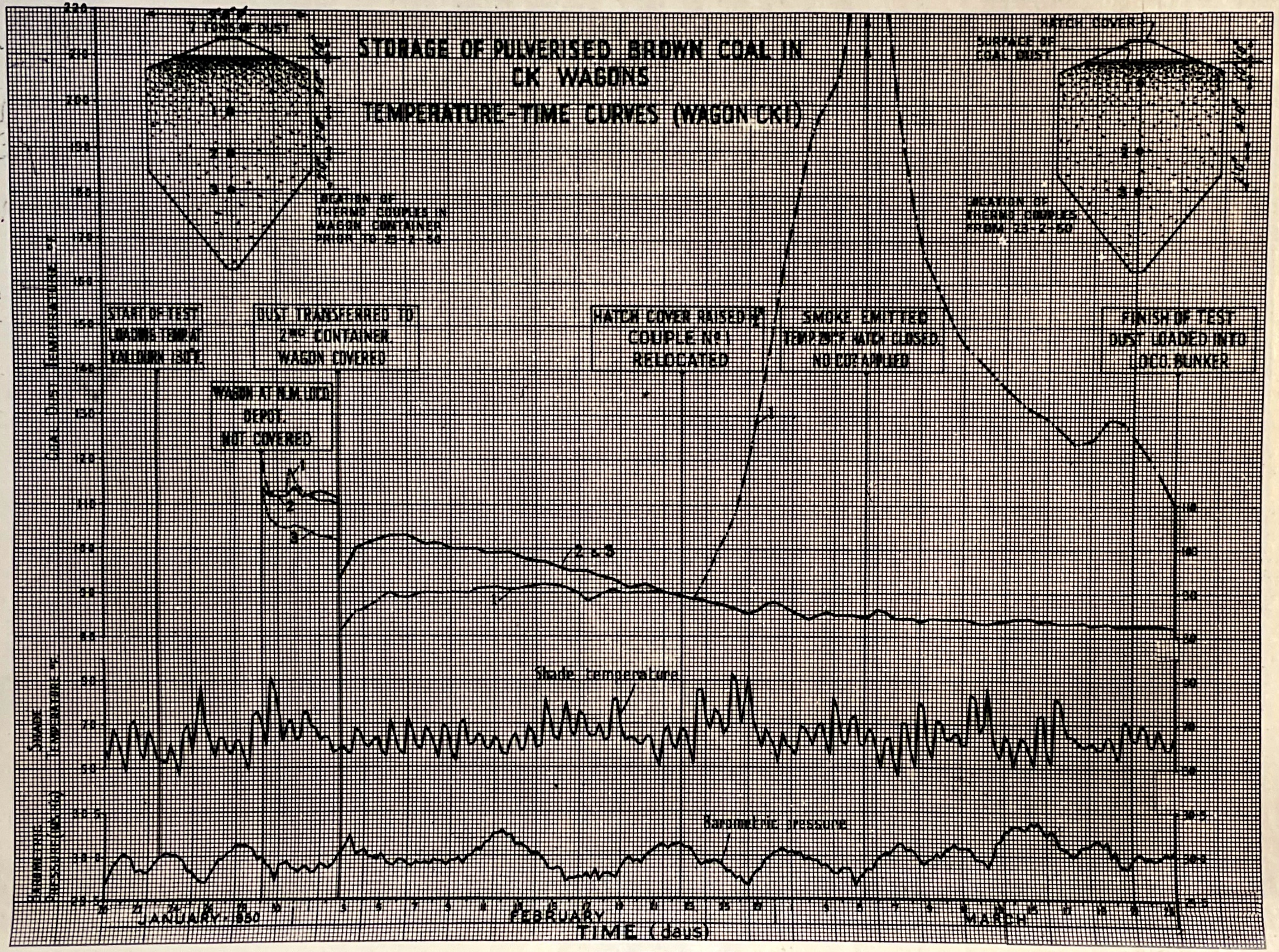

STORAGE OF PULVERISED BROWN COAL IN CK WAGONS
TEMPERATURE-TIME CURVES (WAGON CK1)
7 TONS OF DUST
LOCATION OF THERMO COUPLES IN WAGON CONTAINER PRIOR TO 25-2-50
HATCH COVER
SURFACE OF COAL DUST
LOCATION OF THERMO COUPLES FROM 25-2-50
START OF TEST LOADING TEMP AT YALLOURN 130°F.
DUST TRANSFERRED TO 2ND CONTAINER. WAGON COVERED
WAGON AT N.M. LOCO. DEPOT. NOT COVERED.
HATCH COVER RAISED 1/2" COUPLE No 1 RELOCATED
SMOKE EMITTED TEMP. 29?°F HATCH CLOSED. NO CO2 APPLIED
FINISH OF TEST DUST LOADED INTO LOCO. BUNKER
COAL DUST TEMPERATURE °F
SHADE TEMPERATURE °F
BAROMETRIC PRESSURE (INS. HG)
2 & 3
Shade temperature
Barometric pressure
JANUARY - 1950
FEBRUARY
MARCH
TIME (days)

FIGURE 10

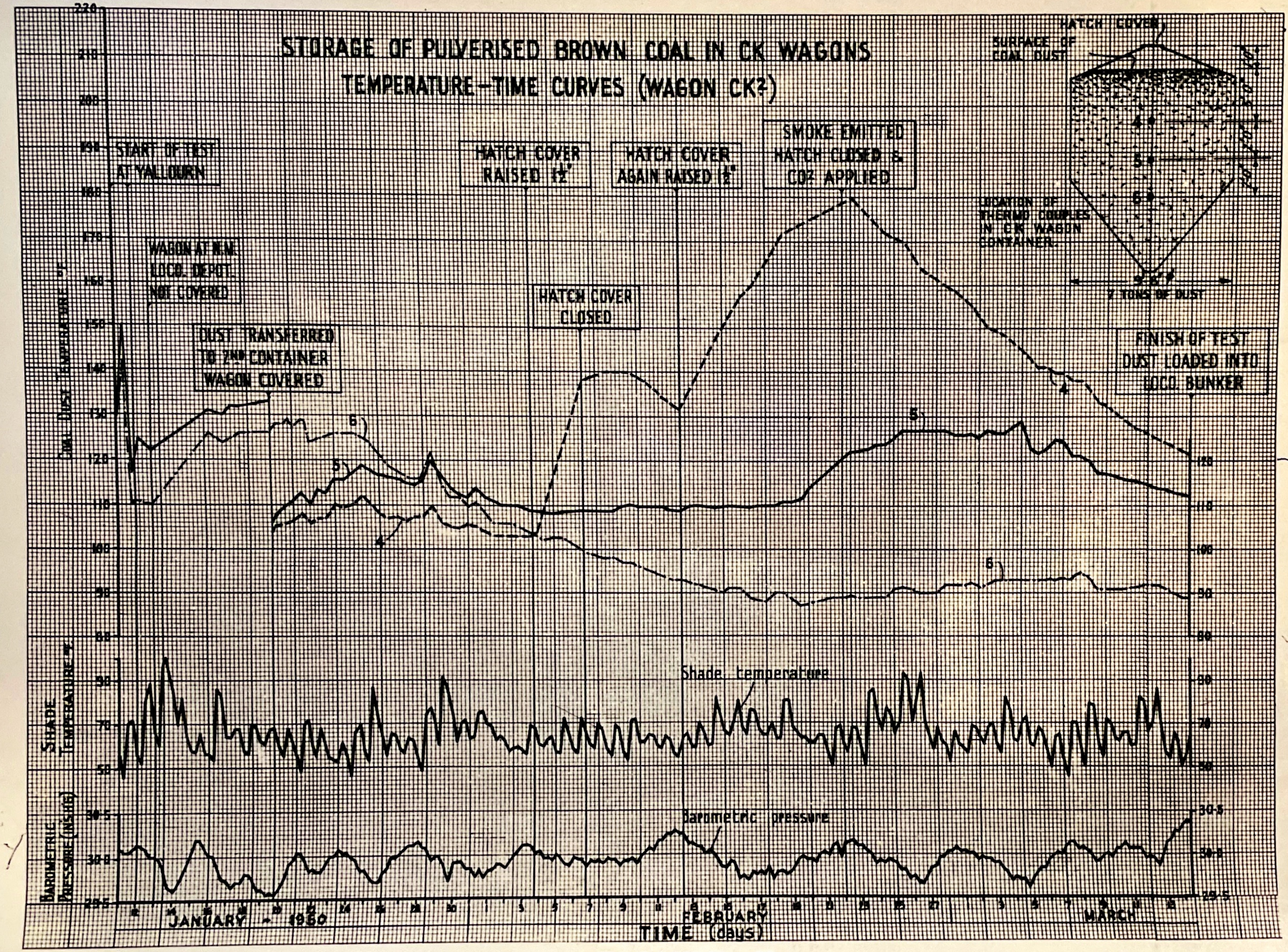

STORAGE OF PULVERISED BROWN COAL IN CK WAGONS
TEMPERATURE-TIME CURVES (WAGON CK2)
START OF TEST AT YALLOURN
WAGON AT N.M. LOCO. DEPOT. NOT COVERED
DUST TRANSFERRED TO 2ND CONTAINER WAGON COVERED
HATCH COVER RAISED 1½"
HATCH COVER AGAIN RAISED ½"
SMOKE EMITTED HATCH CLOSED & CO2 APPLIED
HATCH COVER CLOSED
FINISH OF TEST DUST LOADED INTO LOCO. BUNKER
HATCH COVER
SURFACE OF COAL DUST
LOCATION OF THERMO COUPLES IN CK WAGON CONTAINER.
COAL DUST TEMPERATURE °F.
SHADE TEMPERATURE °F.
Shade temperature
BAROMETRIC PRESSURE (INS.HG)
Barometric pressure
JANUARY - 1950
FEBRUARY
MARCH
TIME (days)

FIGURE II

FIGURE 12:- LAYOUT OF BROWN COAL DUST HOPPERS AT BEISSELSGRUBE

STANDING TESTS - PULVERISED BROWN COAL LOCOMOTIVE 32 'X' AND GRATE FIRED LOCOMOTIVE 30 'X'

Procedure

These tests were conducted as a preliminary to the Dynamometer Car road trials in order to compare the sustained evaporative performances, etc., of the two engines. For the tests the pistons were removed and the piston-rod glands were blanked. Variation of the steam flow was obtained by adjusting the valve openings.

The tests covered a wide range of steaming rates, with a test period of approximately one hour at each. They had the disadvantage of a steady draft, instead of the pulsating condition applying to road locomotives; but experience has shown that this form of testing is a reliable guide to road performances.

With grate - fired locomotive 30 'X' separate tests were conducted with New South Wales Lithgow and Maitland coals. Typical proximate analyses of the fuels used on both engines are as follows:-

Class of Coal	Yallourn Pulverised Brown Coal	Black Coals	
		Maitland	Lithgow
Calorific Value (B.T.U./lb.)	10,540	13,510	11,290
Moisture (%)	5.48	2.40	3.74
Volatile Matter (%)	46.86	36.05	27.44
Fixed Carbon (%)	45.90	53.74	48.86
Ash (%)	1.70	7.81	19.96

Results

A tabulation setting out the principal results obtained is included as Appendix 2. Briefly this shows the following general comparisons:-

STANDING TESTS

Results (Contd.)

Comparison of principal Standing Test results

	32 'X' P.B.C. Firing	30 'X' Grate Firing	
		Maitland Coal	Lithgow Coal
Maximum evaporation (lbs./hr.)	30,240	31,100	26,463
Coal consumption at max. evap. (lbs./hr.)	5,250	4,620	5,240
Superheated steam temperature at max. evap. (^{o}F.)	656	589	597
Boiler horse-power at max. evap.	1,455	1,494	1,272
Equiv. evap. at 26-28,000 lbs. evap. (lbs./lb.)	7.98	9.75	6.78

Steam requirements of turbine - 32 'X'

With one burner operating: 115 to 592 lbs. per hour, representing 1.77 to 4% of the total water evaporated.

With two burners operating: 260 to 1,000 lbs. per hour representing 1.32 to 3.44% of the total water evaporated.

Air Supply for 32 'X' (at maximum evaporation rate)

Primary air - (supplied from turbo-blowers)	48% of total.
Secondary air - Induced under brick-arch	39% of total.
Induced through fire-pan floor	8% of total.
Induced around firehole door	5% of total.

DYNAMOMETER CAR TRIALS

Procedure

Following on the completion of the Standing Tests, Dynamometer Car Trials were conducted on the two engines in order to compare their performances under service conditions. These were carried out on through goods trains on the Melbourne-Bendigo line, which is double tracked throughout and has long and heavy gradients in both directions. In the absence of a brake-locomotive, this section affords some scope for testing under sustained heavy steaming conditions at all speeds.

Test loads were kept as close as possible to the ruling grade limit of 650 tons applying to 'X' class engines and the driving staff was restricted to two selected crews who drove the engines to prescribed cut-off speed charts.

For the power tests these were developed for each engine according to the class of fuel being used in order to utilize the maximum sustained output of the boiler at each speed; but for the efficiency tests a common chart, based on the requirements of normal schedule running was used in all cases. These charts are shown below:-

FOR POWER TESTS

Speed	Cut-off					
	32 'X'		30 'X'			
	P.B.C.		Maitland coal		Lithgow coal	
(m.p.h.)	ins.	%	ins.	%	ins.	%
8	22	78.5	22	78.5	22	78.5
10	21	75.0	21	75.0	21	75.0
15	21	75.0	20	71.5	18	64.3
20	18½	66.1	17½	62.6	16	57.2
25	16	57.2	15	53.5	14	50.0
30	15	53.5	14	50.0	13	46.4
35	14	50.0	13	46.4	12	42.8
40	13	46.4	12	42.8	11	39.3

FOR EFFICIENCY TESTS (Both engines)

Speed	Cut-off	
	Ins.	%
8	22	78.5
10	20	71.5
15	17	60.7
20	14	50.0
25	12	42.8
30	10	37.5
35	9	32.1
40	8	28.8

DYNAMOMETER CAR TRIALS

Efficiency Tests

Appendix 3 shows the results achieved. These are summarised in the following tabulation which shows the average round trip figures:-

	32 'X' Pulverised Brown Coal	30 'X' - Grate Fired		
		Maitland	Lithgow	Wonthaggi
Load & No. of vehicles (tons)	652 = 40	651 = 38	652 = 39	649 = 33
Running time (mins.)	472	462	501	503
Avg. Boiler pressure (lbs./sq.in.)	204	207	202	202
Avg. superheated steam temperature ($^{o}F.$)	635	611	612	605
Equivalent evaporation (lbs./lb.coal)	8.12	9.18	7.74	7.53
Work units per lb.coal (2 x 10^{6} ft.lbs.)	0.186	0.220	0.180	0.172
Calorific value of fuel (B.T.U./lb.)	10,425	13,553	11,489	11,032
Boiler efficiency (%)	75.5	65.8	65.4	66.2
Evaluation - tons of pulverised brown coal equivalent to 1 ton of black coal on basis of:-				
(a) Equivalent evaporation	-	1.13	0.95	0.93
(b) Work units per lb.coal	-	1.18	0.97	0.93
(c) Calorific value	-	1.30	1.10	1.06

Power Tests

The results of these tests are shown graphically in figure 13. From this it will be seen that the following maxima were obtained:-

	Maximum level drawbar H.P. (Corrected for cyl. and wheel dias.)	Evaluation to 30 'X' (Maitland Coal)
32 'X' (pulverised brown coal firing)	1,470 @ 36 m.p.h.	106%
30 'X' (grate firing-Maitland coal)	1,380 @ 29 m.p.h.	100%
30 'X' (grate firing-Lithgow coal)	1,305 @ 27 m.p.h.	95%

DYNAMOMETER CAR TRIALS

Power Tests (Contd.)

The power output of 30 'X' when operating on Maitland coal was governed by spark arrester blockage and any attempt to increase its power beyond the figure shown resulted in un-scheduled stops to clean the netting.

The maximum output of the pulverised fuel engine was governed by the capacity of the firing equipment and not by the ability of the engine to burn more fuel and evaporate more water.

General observation on performance of locomotive 32 'X' during trials

Power and Efficiency

The trials demonstrated that pulverised brown coal is a satisfactory fuel for suitably equipped locomotives with fire-boxes of proportions approximating those of the 'X' class. These would include the X, N, R, S and H classes. They also showed that the maximum draw-bar power developed by these engines on brown coal dust should at least equal and most likely exceed by 5 - 10% that which could be produced with Lithgow and Maitland coals.

The fuel consumption of the pulverised fuel engines should be about 4 - 7% lower than their grate fired equivalents burning Lithgow or Wonthaggi coals; but would be about 15% greater than those using Maitland coal.

Operation of the equipment

Throughout the trials no trouble was experienced with the operation of the equipment which proved to be as reliable as any other equipment on the locomotive.

The test crews quickly became familiar and expert in the operation of the firing equipment. It was much appreciated by them as it had the following advantages over black coal firing without any associated disabilities:-

Improved cab cleanliness,
Reduced noise,
Reduced fatigue - no hand firing and no fire-cleaning,
Uniformity of fuel,
Better control,
Improved steaming,
Elimination of smoke,
Elimination of spark hazard and spark arrester cleaning.

The duties of the fireman naturally are much less arduous and more congenial on the pulverised fuel engine than on its grate fired equivalent, not only because manual firing is eliminated; but also because the cleaning of fires and spark arresters is unnecessary. The fireman thus can concentrate on his firing technique, the operation of the injectors and the observance of signals.

DYNAMOMETER CAR TRIALS

Swallow's Nests

As mentioned previously the principal trouble experienced by the Germans in operating their pulverised fuel locomotives, was the rapid formation of ash deposits on their tube plates. These were termed "swallow's nests", because of their likeness to that form of construction and built up so rapidly that tubes became badly blocked after less than 100 miles of running, notwithstanding the frequent use of steam and sand blowers.

In our case we anticipated trouble of this nature to a lesser degree; but expected that it would be kept within reasonable bounds by the lower ash content of our fuel and our better firebox design. On the other hand it was thought that the disability would be aggravated by the coarseness of our fuel.

The tests have shown that we should not experience any appreciable trouble in this respect, provided a good coarse sand is applied about each 25-30 miles and the tubes are manually cleaned each 1,000 miles. This period could probably be extended by brushing-down the tube-plate - with a long handled wire brush - at regular intervals.

Figure 14 shows the typical condition of the tube-plate - 400 miles after its previous cleaning - without any intermediate brushing and with unsuitable battery box sand as the blasting medium.

The extent to which the deposits had accumulated on both the tubes and the superheater element ends after 1,550 miles of running under the same conditions, is shown in figure 15. From this it may be seen that some tubes are almost completely blocked and that there are large deposits on the ends of the superheater elements.

These had no apparent influence on the steaming of the locomotive, however; but from then onwards the deterioration probably would have been rapid.

Some details of typical deposits are shown in figure 16. These show a resemblance to the "swallow's nest" construction when the tube is completely blocked.

They are comprised of minute particles of ash sintered together and with little bond to the tube-plate or element end. For this reason they are easily removed - some deposits fall off of their own accord - and every effort should be directed towards retarding their growth by the regular application of a coarse sand through the peep-hole in the fire-door.

Fuelling

Throughout the test the locomotive bunker was fuelled direct from 'CK' wagons in the manner described on page 25, the operation involving up to one hour. This method of refuelling, however, would be unsuitable for service conditions which require overhead hopper storages from which locomotives could be refuelled within 10 minutes.

The development of an efficient fuel handling technique and re-fuelling process is now considered to be the major problem associated with this form of firing; but some prototype units - patterned on German experience will shortly be installed and a successful outcome is anticipated.

DYNAMOMETER CAR TRIALS

Explosion Hazard

Throughout the trials and the subsequent service operation of the locomotive, which have extended over a period of nearly 12 months, no case of an explosion, even of a minor nature, has been experienced. This result, no doubt is largely due to the interlocking of the turbine throttle - valve and the conveyor-screw clutch levers, which ensures an efficient purging of the ducts, burners and combustion space, both before engaging and after disengaging the burners.

The burners can be re-lit from the hot furnace, without difficulty, after being shut-down for periods of up to 3/4 hour, as a small amount of unburnt dust always accumulates in the well of the firepan during the shutting-down operation. This smoulders for a long period and is fanned into a blaze sufficient to ignite the incoming fuel when the blowers are restarted.

Should immediate ignition not take place however, the instructions (R.S.49/9376) stipulate that the conveyor screw clutches should be quickly disengaged if the burners do not light within 2 or 3 seconds. After purging the furnace the procedure then would be, to light-up from oily waste in the prescribed manner.

Spontaneous Combustion

No case of spontaneous combustion has been experienced, either in the transport of the fuel in the 'CK' wagons, during its subsequent storage in them until used, or in the locomotive bunker, except with the prolonged storage tests described on page 26.

The only precautions taken against this hazard, apart from designing both the wagons and the bunkers to ensure a free flow of dust and prevent the formation of "pockets", was to completely empty the wagons each time before returning them to Yallourn for refilling and to keep them sealed during the transport and storage period.

Naturally the fuel was used shortly after it was received; but in some cases an interval of 12 days elapsed from the time a wagon was filled at Yallourn until it was used.

Firing Conditions

A striking feature of the tests was the complete control by the fireman over the firing of the pulverised fuel engine and the ease with which he met the most severe demands of the driver. This was particularly noticeable on booster gradients, when the requirements of both the booster and the engine could be met without trouble for unlimited periods and top steam pressure could be maintained against the action of the injectors. Generally, advantage was taken of these gradients to build up the water level if a high speed steaming section lay ahead.

Combustion

Almost perfect combustion conditions were experienced on the pulverised fuel engine throughout the tests. There was an absence of smoke at all times and the main concern was to limit the excess air. The following random gas analyses may be regarded as typical of those experienced over the full range of speeds encountered in the tests and show how the CO content of the gas is low at all speeds:-

DYNAMOMETER CAR TRIALS

Combustion (Contd.)

Speed (m.p.h.)	Gas Analysis CO_2 (%)	O_2 (%)	CO (%)
10	9.2	10.4	0.4
11	14.2	4.5	0.2
12	14.4	4.8	Nil
15	16.0	3.0	0.2
15	9.4	10.1	Nil
20	11.2	8.1	Nil
20	11.2	8.2	Nil
25	14.2	5.0	Nil
25	15.2	3.8	Nil
25	12.2	6.2	0.8
30	15.7	2.8	Nil
30	9.4	10.2	0.6
35	15.7	3.5	0.2

CURRENT RESEARCH

Following on the recent agreement by the State Electricity Commission to increase our supply of pulverised brown coal to 28 tons per day as soon as facilities can be made available, the Commissioners approved of the following works being carried out with a view to extending the scope of our trials:-

(a) The conversion of a new 'N' class locomotive, using the second equipment imported from Germany,

(b) The construction of an additional 5 - 'CK' wagons to handle the increased quantity of fuel. This will bring our total of these wagons up to 7,

(c) The erection of two 56 ton overhead fuel storage hoppers, one at North Melbourne locomotive depot and one at the Yallourn Yard. These will provide experience in the overhead re-fuelling of locomotives and enable research to be conducted into the best method of safely storing and handling the fuel on a large scale.

It is hoped to complete these works within about 12 months, when the State Electricity Commission expects to be in a position to make the increased fuel supplies available.

The two converted locomotives, then would be operated on the Melbourne-Yallourn Service, with the regular roster of drivers, for an extended service trial to ascertain their performances under regular operating conditions.

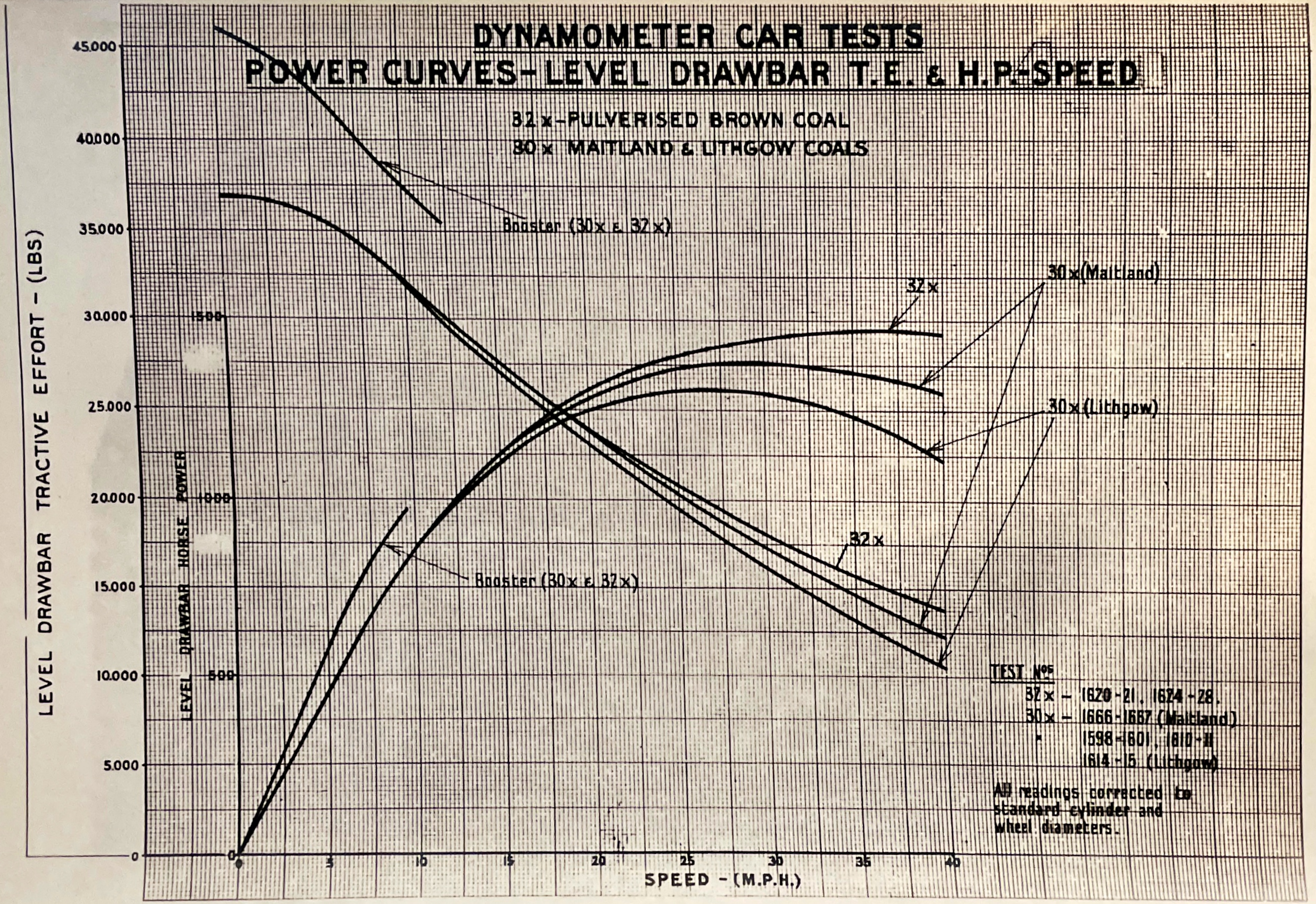

DYNAMOMETER CAR TESTS
POWER CURVES - LEVEL DRAWBAR T.E. & H.P. - SPEED
32 x - PULVERISED BROWN COAL
30 x MAITLAND & LITHGOW COALS
LEVEL DRAWBAR TRACTIVE EFFORT - (LBS)
LEVEL DRAWBAR HORSE POWER
SPEED - (M.P.H.)
Booster (30x & 32x)
Booster (30x & 32x)
32x
32x
30x (Maitland)
30x (Lithgow)
TEST Nos
32x - 1620-21, 1624-28.
30x - 1666-1667 (Maitland)
" 1598-1601, 1610-11
1614-15 (Lithgow)
All readings corrected to standard cylinder and wheel diameters.

FIGURE 13

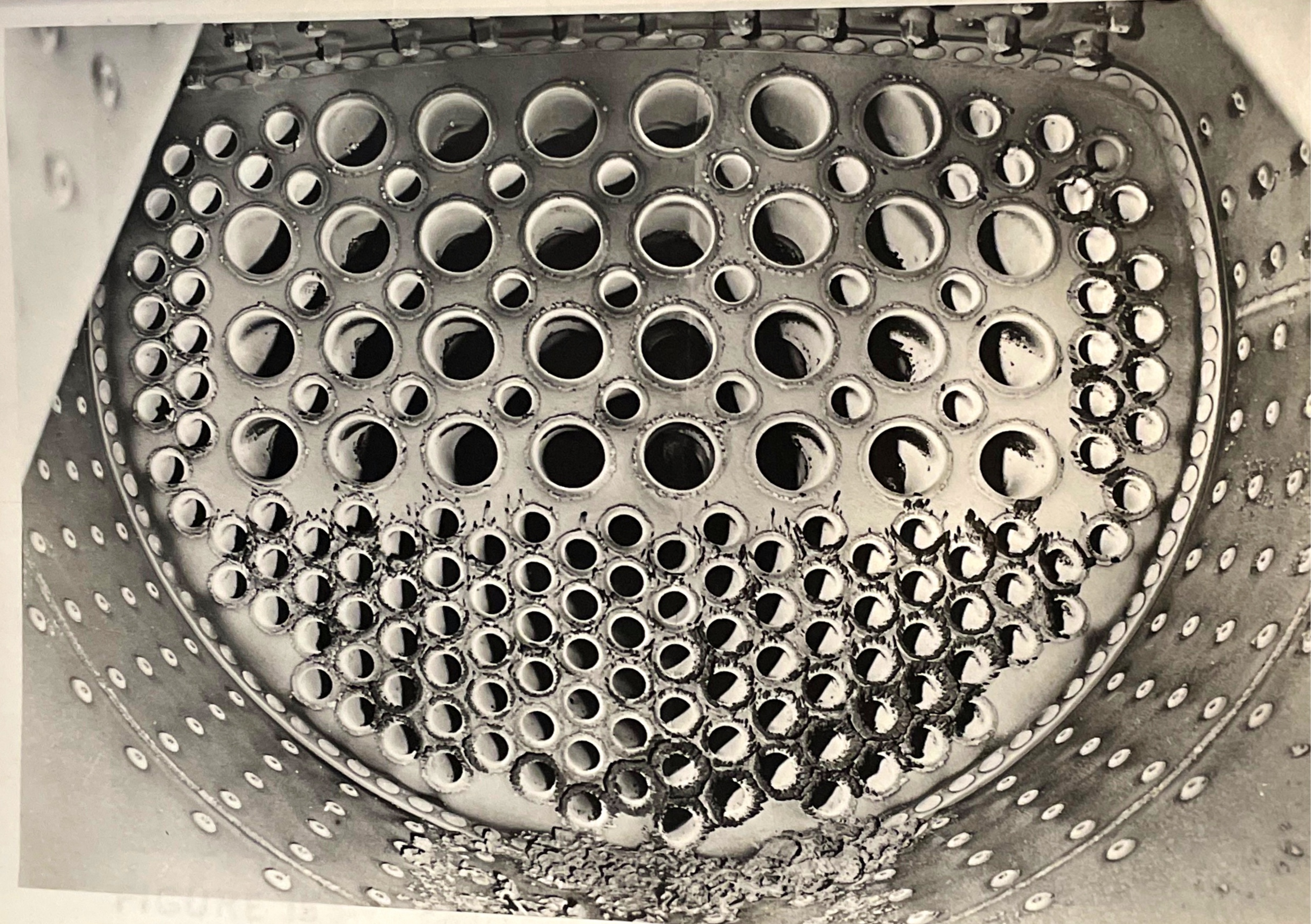


FIGURE 14 :- "

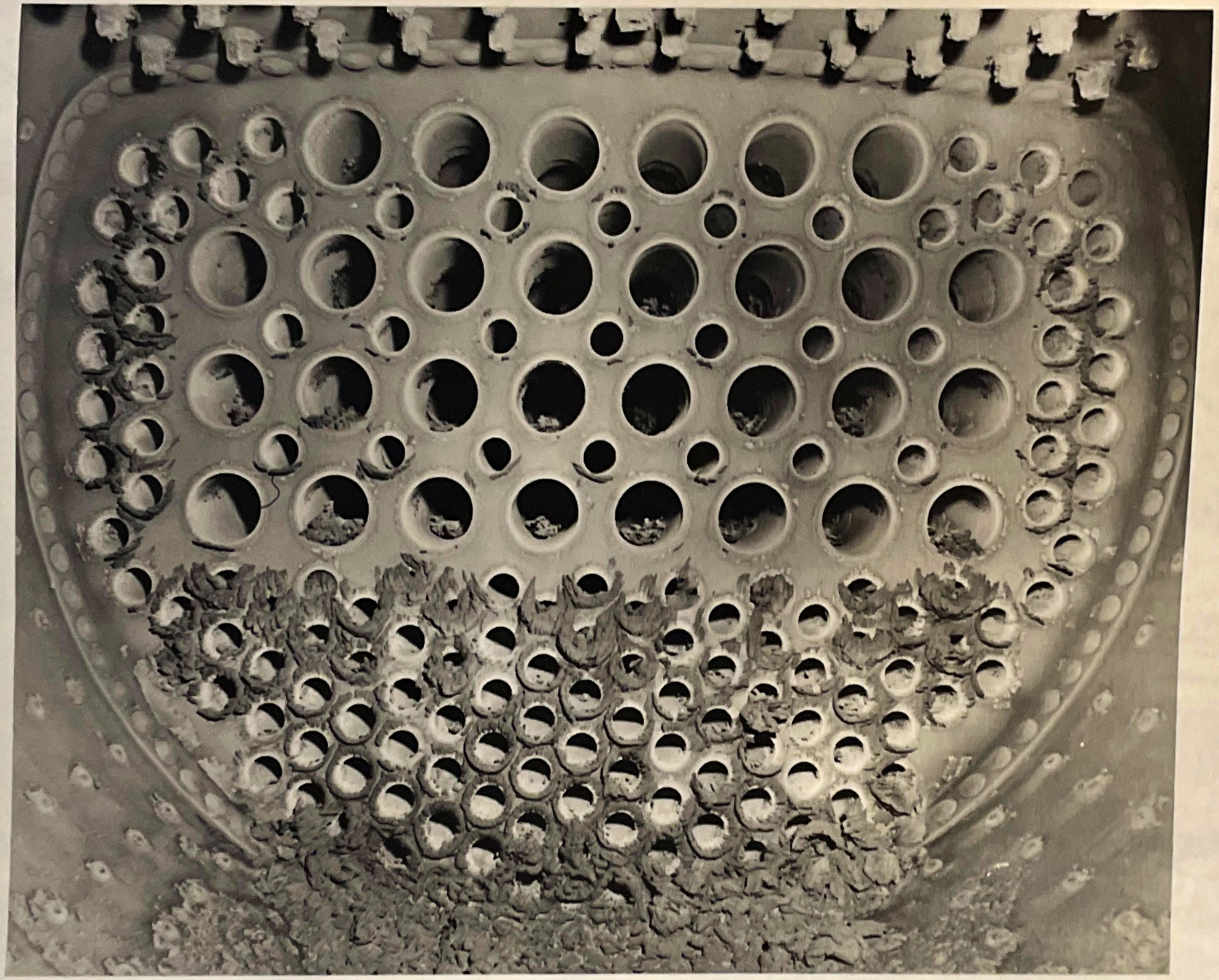


FIGURE 15 :- "SWALLOWS NESTS" DEPOSITS ON THE TUBE PLATE OF "32 X"
(1550 MILES AFTER CLEANING)

FIGURE 16 - TYPICAL "SWALLOWS NEST" FORMATIONS
(1550 MILES AFTER TUBE-CLEANING)
APPROX. ½ SIZE

ECONOMIC SURVEY - THE PULVERISED BROWN COAL FIRING OF SELECTED GROUPS OF VICTORIAN RAILWAYS LOCOMOTIVES

This has been developed under the following paragraphs:-

1. Classes of locomotives suitable for conversion and annual fuel requirements.
2. Anticipated availability of pulverised brown coal from briquetting factories.
3. Estimated locomotive conversion costs.
4. Estimated maintenance costs arising from pulverised brown coal firing equipment, etc.
5. Calculated fuel costs at likely refuelling points.
6. Evaluation of pulverised brown coal to various classes of black coals as locomotive fuels.
7. Ash handling and disposal costs.
8. Availability of pulverised brown coal locomotives.
9. General factors which favor pulverised brown coal firing.
10. Comparative costs of operating selected groups of locomotives on pulverised brown coal and black coals:-
    - (a) 44 'X' class (29 existing and 15 new).
    - (b) 70 'R' class (new).
    - (c) 100 'N' class (30 existing and 70 new).
11. Lines to be served by proposed pulverised brown coal locomotives.

1. Classes of locomotives suitable for conversion and annual fuel requirements

Essentials for success in the pulverised brown coal firing of locomotives are ample firebox volume and adequate flame length. Of our existing stock, only the H, S and X classes have these characteristics; but the new 'R' and 'N' classes, as well as the existing 'N' class when fitted with combustion chamber boilers, also would be suitable. The total number of engines in these classes, both existing and on order or under construction, together with their anticipated annual mileages and fuel consumptions are shown in the following table:-

ECONOMIC SURVEY

Classes of locomotives suitable for conversion and annual fuel requirements (Contd.)

Class of locomotive	No.	Anticipated annual mileage per loco.	Anticipated annual consumption of pulverised brown coal.	
			Per loco. (tons)	Per group (tons)
H	1	55,000	4,000	4,000
S	4	67,000	3,000	12,000
X (extg. booster)	29	33,000	2,000	58,000
X (new, non-booster)	15	33,000	1,700	25,000
R (new)	70	37,000	1,380	97,000
N (new) N (extg.)	20 + 50 = 70 30	23,000	970	97,000
TOTALS:	219	-	-	293,000

2. Anticipated availability of pulverised brown coal from briquetting factories

As previously mentioned the pulverised brown coal supplied for locomotive 32 'X' was obtained from electrical precipitators installed in the drier stacks at the Yallourn Briquetting Factory. This material has the following advantages over brown coal dust obtained by the mechanical pulverisation of briquettes:-

(a) A higher calorific value, of approximately 10,400 B.T.U. as compared with 9,500 for briquette material, due to a lower moisture content,

(b) A lower cost, as the pulverising process is avoided.

State Electricity Commission officers generally agree that the quantity of precipitated dust collected in the Yallourn Briquetting Factory approximates 10% of the total briquette output and anticipate that 7-10% will be collected from the new Morwell Factories.

ECONOMIC SURVEY

Anticipated availability of pulverised brown coal from briquetting factories (Contd.)

On this basis the following tabulation shows the total amount of the dust that is now collected at Yallourn and the progressive increases as each stage of the new Morwell Factory comes into operation:-

Year	Anticipated annual out-put of briquettes (tons)	Anticipated annual out-put of pulverised brown coal from precipitators.	
		7% basis (tons)	10% basis (tons)
1950 Yallourn	540,000	38,000	54,000
1953-4 Yallourn plus Morwell No.1	550,000 630,000 1,180,000	83,000	118,000
1954-5 Yallourn plus Morwell Nos.1 and 2	550,000 690,000 690,000 1,930,000	135,000	193,000
1956-7 Yallourn plus Morwell Nos.1 - 3	550,000 690,000 690,000 690,000 2,620,000	183,000	262,000
1958-9 Yallourn plus Morwell Nos.1 - 4	550,000 690,000 690,000 690,000 690,000 3,310,000	232,000	331,000

Thus the requirements - 293,000 tons per annum - of the group of 219 locomotives listed under paragraph (1) could be progressively supplied from this source as indicated. They could be met in full, however, only with an overall collection of 9% of the briquette output and at the completion of the Morwell No.4 Factory, which is expected by 1958-9.

ECONOMIC SURVEY (Contd.)

3. Estimated locomotive conversion costs

Pulverised brown coal firing equipment cost

The "STUG" equipment installed in locomotive 32 'X' was purchased from the German firm of Henschel and Son; but in view of the uncertainty of future supplies from this source, this survey has been based on a quotation for local manufacture of equipments from drawings supplied by this Department.

The quoted figure was £5,000 per locomotive unit for quantity manufacture.

Locomotive conversion cost

It is estimated that the following conversion costs would apply if locomotives were converted whilst undergoing a heavy repair in our Workshops. They allow appropriate credits for work that normally would then be due; but would be rendered unnecessary by the conversion, such as tender, ashpan grate, arch and door repairs:-

S & H	Class	£5,000 each nett.
X & R	"	3,200 " "
N	"	2,600 " "

Total cost of equipment and conversion

S & H	Class	- £5,000 + 5,000	=	£10,000 each.
X & R	"	- £5,000 + 3,200	=	£8,200 "
N	"	- £5,000 + 2,600	=	£7,600 "

4. Estimated maintenance costs arising from the pulverised brown coal firing equipments, etc.

These have been based on the current maintenance charge of 28 pence per mile applying to 'X' class locomotives with a life of 25 years.

As the cost of a new pulverised brown coal locomotive exceeds that of its grate-fired equivalent by approximately 15%, a proportional increase in maintenance charge should be ample provision.

Thus the added maintenance of an 'X' class pulverised brown coal locomotive would be 4 pence per mile or £550 a year, which represents 5/6 per ton of coal dust consumed. Proportional figures applying to other classes of locomotives, based on fuel consumption and annual mileage are shown below:-

Class of locomotive	Added maintenance charge	
	Per ton of pulv. brown coal (s. d.)	Per mile (pence)
X (booster)	5/6	4.0
X (non-booster)	6/6	4.0
R	6/9	3.0
N	6/0	3.0

Estimated maintenance costs arising from the pulverised brown coal firing equipment, etc. (Contd.)

A detailed survey of all the items involved in these charges and a comparison with available German figures, has shown that the allowances not only are ample; but also provide for any additional tube-cleaning that may be necessary.

5. Calculated locomotive fuel costs at likely refuelling points

(a) Basic fuel costs

Pulverised brown coal - Present indications are that the State Electricity Commission will make this material available from the Yallourn factory at the ruling rate for briquettes - now 30/- per ton f.o.r. Yallourn. It has been unofficially suggested however that the price of dust from Morwell factories may be higher, because of increased equipment charges.

Accordingly a figure of 30/- has been taken for 50,000 tons from Yallourn and 37/6 per ton for all supplies from Morwell.

Lithgow Coal - Taken at the current rates of 66/- per ton f.o.r. Tocumwal and 63/6 per ton f.o.r. Wodonga.

State Mine Coal - Taken at the current rate of 55/- per ton f.o.r. Wonthaggi.

Maitland coal - Taken at the current rate of 75/- per ton f.o.r. Melbourne or Geelong.

Imported coals - Taken at the contract price for South African and Indian coals to be imported to Victoria during 1950-51, viz:-

Indian coal - £5.11.8 per ton c.i.f. Melbourne plus 13/- per ton unloading charge.

South African Coal - £5.16.4 per ton c.i.f. Melbourne plus 13/- per ton unloading charge.

Government subsidy on imported coals

Imported coals are now subsidised by the State and Federal Governments and are charged to the Victorian Railways at the current New South Wales parity rate. This is now only £3.13.8 per ton f.o.r. Melbourne, so that the average Government subsidy is £2.13.4 per ton.

For the purpose of this survey, however, the subsidy has been disregarded, in order to arrive at the true economics of pulverised brown coal firing from a National standpoint. Figures have also been taken out, however, to show how Departmental finances would be effected by the conversion of groups of locomotives and those have been based on the supply of imported coal at the current New South Wales parity rate.

(b) Transport charges

Black coal - The current departmental charge for transporting black coal in general-purpose wagons is 1.33 pence per contents ton-mile. These wagons have a low empty return factor of only 10% and their average ratio of gross tonnage (including empty returns) to load = 1.618 to 1.

The transport charge per gross ton-mile therefore $= \frac{1.330}{1.618} = 0.823$ pence.

Pulverised brown coal - The transport of this material involves the use of special-purpose wagons with a higher ratio of gross weight to load and a 100% empty return factor. In total the ratio of gross weight (including empty returns) to load is 2.85 to 1.

The appropriate transport charge for this fuel, based on the current black coal figure, therefore = 2.85 x 0.823 = 2.34 pence per contents ton-mile.

(c) Handling and storage charges

Black coal - The current rates are:-

2/4 per ton at North Melbourne, Ararat and Wodonga - where mechanical plants are installed and
4/3 per ton elsewhere, where manual handling is involved.

Pulverised brown coal

Storage. The estimates provide for the following storages:-

Overhead hopper storages (to enable locomotives to be rapidly refuelled) 1 1/2 and 2 days demand at North Melbourne and 3-6 days demand at other refuelling points.

Mobile Storage - in 'CK' wagons - 2 days demand at North Melbourne and 3-4 days demand at other centers.

Emergency Storage - to provide against dislocation of supplies of pulverised brown coal from Yallourn or Morwell.

Allowance has been made for the bulk storage under cover at North Melbourne of 3-4 weeks requirements in the form of briquettes and an emergency pulverising plant with storage hopper and facilities to load pulverised briquettes into 'CK' wagons for despatch to refuelling points as required.

The total charges for all these storage provisions per ton of pulverised brown coal consumed are:-

For 'X' & 'R' classes - 2/6 per ton.
For 'N' class - 3/- per ton.

The higher figure for the 'N' class results from the wider distribution that is involved.

Handling. The combined charge (including all costs) for discharging pulverised brown coal from 'CK' wagons into the overhead hoppers and refuelling locomotives from these hoppers, is estimated at 1/- per ton of coal consumed.

ECONOMIC SURVEY

Handling and storage charges (Contd.)

Storage plus handling. The combined figures for these items therefore are:-

For 'X' & 'R' classes - 3/6 per ton.
For 'N' class - 4/- per ton.

(d) Total fuel costs - loaded into loco. bunkers

Appendix 4. Shows the unit costs applying to various coals, as loaded into locomotive bunkers, at the principal refuelling points throughout the State. These have been computed on the foregoing bases and will be used in calculating the fuel costs involved in operating the selected groups of locomotives.

6. Evaluation of pulverised brown coal to various classes of black coals as locomotive fuels

The following figures were obtained from the Dynamometer car efficiency test results tabulated in appendix 3 and for the reasons already stated are assumed to apply to the Morwell as well as the Yallourn dust:-

Class of black coal	Calorific value of black coal (B.T.U.)	Tons of pulverised brown coal equivalent to 1 ton black coal	Calorific value of pulverised brown coal (B.T.U.)
State Mine (Dudley & Western Areas)	11,030	0.93	10,400
Lithgow	11,500	0.96	10,400
Maitland	13,550	1.15	10,400

For the imported coals the Lithgow evaluation may be used as a base with a correction for the difference in calorific values as follows:-

Indian Coal (12,010 B.T.U.) $= 0.96 \times \frac{12010}{11500} = 1.00$

South African Coal (12,300 B.T.U.) $= 0.96 \times \frac{12300}{11500} = 1.03$

For simplicity, however, and to keep the survey conservative, the following average figures have been used:-

For goods locomotives - 1 ton pulverised brown coal is equivalent to 1 ton of State Mine, Lithgow or Imported coals.

For passenger locomotives - 1.15 tons of pulverised brown coal is equivalent to 1 ton Maitland coal. 1.05 tons pulverised coal is equivalent to 1 ton South African coal.

ECONOMIC SURVEY

7. Ash handling and disposal costs

Pulverised brown coal locomotives do not produce ashes.

The current ash-handling cost for black coal burning locomotives, averaged throughout the State, is 5/6 per ton.

These ashes have a value only as filling material that otherwise could be obtained at 5/- per ton; but generally an average haul of 50 miles, with empty return of trucks, is involved. The appropriate transport charge would approximate 1.7 pence per contents ton-mile and the disposal cost approximately 7/- per ton of ashes.

The nett debit for ash-handling and disposal is therefore about 5/6 + 7/- - 5/- = 7/6 per ton of ashes.

Approximately 1 ton of ashes is now produced for each 4 1/2 tons of coal burned, so that the ash-handling and disposal cost per ton of black coal consumed is $\frac{7/6}{4\ 1/2}$ = 1/8.

8. Availability of pulverised brown coal locomotives

This survey provides for whole groups of locomotives to be converted and for refuelling points to be available whereever required. The operation of the pulverised brown coal locomotives therefore should be as flexible as that of the black coal units and their general utilization also should be as high.

Loss of availability due to routine depot and workshop inspection and maintenance, in a general way should not exceed that of their black coal equivalents - notwithstanding the added equipment - as this could be attended to concurrently with the inspection and maintenance of the balance of the engine.

Some added loss of availability due to unpredicted failures of the firing equipments and to intermediate furnace brickwork renewals, however, must be anticipated; but this should be offset by a general improvement in running arising from better steaming and the elimination of fire and spark arrester cleaning.

Such reductions in running time naturally would show a corresponding reduction in crews wages; but this has not been shown as a credit in this survey, which assumes equal availability, utilization and running times for both types of engines.

9. General factors which favor pulverised brown coal firing

Apart from the advantages already stated for pulverised brown coal firing, the following are also important. It is not possible to assess their values however and therefore they have not been included in the economic survey:-

(a) Elimination of manual firing and improved cab conditions,
(b) Elimination of spark hazard,
(c) Elimination of smoke nuisance,
(d) Use of locally produced fuel not subject to the frequent dislocation of supply now associated with black coal production.

The only apparent disadvantages are associated with the handling and storage of this fuel; but these should be overcome to an appreciable extent with the provisions allowed for in the estimates.

ECONOMIC SURVEY

10. Comparative costs of operating selected groups of locomotives on pulverised brown coal and black coal

(a) Group No.1 - 44 'X' class (29 existing and 15 new).

(i) Fuel Costs

On the basis of the unit annual mileage of 33,000 that now applies to 'X' class locomotives, this group would require each year approximately 83,000 tons of black coal of Lithgow, State Mine or Imported quality, or alternatively the same quantity of pulverised brown coal.

The position regarding future supplies of black coals of the above classes is uncertain; but the following figures show the trend of increased imports to offset shortages in local supply:-

Year	Local coal used (tons)	Imported coal used (tons)	% imported to total
1948-9	329,000	48,000	13
1949-50	185,000	168,000	48
1950-1 (anticipated figures)	135,000	241,000	64

The position would be further aggravated by the introduction of coal - burning 'R' class locomotives, principally to replace the oil burning 'A2' class.

The Comptroller of Stores considers that it will be necessary to import large quantities of black coal for our locomotives for some years and agrees with the assumption that the conversion of our 'X' class locomotives to pulverised brown coal firing would obviate the need to import the equivalent of their fuel requirements for some years to come.

Accordingly the economics for this group could be based wholly on imported coal at a landed cost of £6.7.0 per ton; but in order to keep the survey slightly on the conservative side, they have been based on the 90% imported coal supply and distribution likely to apply during 1950-1 to 'X' & 'C' class engines other than those operating on the Melbourne-Traralgon and Melbourne -Geelong sections.

This is the basis of Appendix 5 - tabulation 1, which sets out the quantities of black and brown coals that would be taken at each refuelling point in the State, after allowing for the electrification of the Melbourne-Traralgon and Melbourne-Geelong sections and the allotment of the 15 new 'X' class engines to services now operated by 'C' class locomotives.

It also sets out the total fuel costs for the group, based on the unit rates shown on Appendix 4. These are:-

Black coal - £535,990 per annum.

Pulverised brown coal - £266,600 per annum.

ECONOMIC SURVEY

Group No.1 - 44 'X' class (Contd.)

(ii) Comparison of all relevant charges

Tabulation 2 - Appendix 5 - shows a comparison of all the relevant charges involved in operating this group of locomotives on black and pulverised brown coals, respectively.

This embodies all the factors set out in the foregoing paragraphs; but excludes those charges that are common to both types of locomotives, such as normal maintenance, lubricants, crew wages, etc.

It will be seen that, from a National viewpoint, an annual saving of £227,600 - based on a 90% imported coal figure - would result from the operation of this group of locomotives on pulverised brown coal. This saving is equivalent to £5,170 per locomotive and £2.14.10 per ton of coal consumed.

From a Railway standpoint much of this saving would be offset by the Government subsidy on imported coals, if it still applied, and the resultant saving would fall to £30,100 a year.

(iii) Total expenditure involved

Tabulation 3 - Appendix 5 - sets out the total expenditure that would be necessary before these locomotives could be operated on pulverised brown coal. The appropriate annual charges on these costs however have already been included in the economic survey shown on Tabulation 2. Briefly this expenditure falls in the following subdivisions:-

	£
Conversion of 43 locomotives (1 unit already converted)	385,000
Construction of 200 special purpose transport wagons - 'CK' class	280,000
Provision of overhead storage hoppers etc., at refuelling points	86,000
Provision of emergency briquette storage and pulverising plant at North Melbourne	50,000
Total:	801,000
10% contingency for rising prices, etc.	80,000
Grand Total:	881,000

THE ABOVE COST FOR 'CK' WAGON CONSTRUCTION IS BASED ON NEWPORT MANUFACTURE. IF THIS WORK WERE CARRIED OUT BY AN OUTSIDE CONTRACTOR, THE UNIT RATE FOR THIS ITEM WOULD PROBABLY RISE TO ABOUT £2,600.

ECONOMIC SURVEY

Comparative costs of operating selected groups of locomotives on pulverised brown coal and black coal (Contd.)

(b) Group No.2 - 70 'R' class - New.

(i) Fuel costs

As this group of locomotives will operate on passenger services, it is considered that as grate-fired units they will have to be fired with a good class of black coal of Maitland or South African quality, in order to maintain schedules. It is felt that State Mine, Lithgow or Indian coals would be unsuitable for them, notwithstanding their large grates and stoker firing, because of the fire-cleaning that would be necessary at intermediate points.

Extreme difficulty has been experienced for some years in obtaining sufficient Maitland coal to run even special trains in this State and there appears to be little prospect of improvement in this position. Accordingly the economics of this group have been based on the use of South African coal at a landed cost of £6.9.4 per ton f.o.r. Melbourne.

1.05 tons of pulverised brown coal should be the equivalent of 1 ton of South African coal on this class of locomotive and its rate has been taken at the 37/6 per ton f.o.r. figure applying to Morwell.

Appendix 6 - Tabulation 1 - has accordingly been prepared on these bases. It sets out - for both types of coal - the annual fuel requirements of the group, based on an anticipated annual mileage of 37,000 that now applies to the A2 oil-burners and an annual black coal consumption of 1,320 tons per locomotive. It also shows the quantity that it is expected will be taken at each refuelling point and the total cost of each class of fuel, based on the unit costs shown on Appendix 4. The distribution shown allows for the electrification of the Melbourne-Traralgon and Melbourne-Geelong lines.

In the case of this group it will be seen that the substitution of pulverised brown coal for South African coal would show an annual fuel saving of approximately £289,400.

(ii) Comparison of all relevant charges

National viewpoint

This is shown on Tabulation 2 - Appendix 6, which indicates that from a State or National viewpoint, the following overall savings would result from the conversion of this group to pulverised brown coal firing as compared with their operation on South African coal at a landed cost of £6.9.4 per ton:-

For group of 70 locomotives - £224,800 per annum.

Per locomotive - £3,210 per annum.

Per ton of pulverised brown coal consumed. - £2. 6. 6.

ECONOMIC SURVEY

Group No.2 - 70 'R' class - New (Contd.)

Railway Viewpoint

These savings are slightly less than the amount of Government subsidy that would be paid if the present figure of £2.15.8 per ton still applied to South African coal and from a Railway viewpoint a slight annual loss would therefore result from the conversion of this group.

This would amount to approximately £34,000 a year or 7/- per ton of pulverised brown coal consumed, after all relevant costs had been met in full.

An important compensating factor would be the advantages associated with pulverised brown coal firing - as already enumerated - for which no monetary benefit has been claimed.

(iii) Total expenditure involved

A total expenditure of £1,278,000 would be involved before this group of locomotives could be operated on pulverised brown coal and details of this cost are shown on Appendix 6 - Tabulation 3. The charges arising from this expenditure however, have already been included in the economic survey dealt with in the previous paragraph.

(c) Group No.3 - 100 'N' class (70 new 30 existing).

(i) Fuel costs

This group of locomotives will be utilized on goods services and can burn any class of coal offering. They could not be converted before 1957-8 however, because of the fuel supply position and for the purpose of this survey it is assumed that our demand for black coal will have been appreciably reduced by then as a result of the main-line electrification projects now in course, the introduction of diesel shunters and the conversion of the 'X' and 'R' class groups of locomotives to pulverised brown coal firing.

It should therefore be possible to obtain all the black coal required for our remaining grate-fired locomotives from local sources; but as most of it still will have to come from New South Wales, the conversion of further units to pulverised brown coal firing would obviate the need to bring a corresponding quantity of black coal from that State.

Accordingly the 'N' class survey has been based on Lithgow coal at ruling prices. One ton of pulverised brown coal has been taken as the equivalent of one ton of this class of coal and as the requirements of the group would have to be supplied from Morwell, a rate of 37/6 per ton f.o.r. Morwell has been applied to it.

The annual mileage of this group has been taken as 23,000 per locomotive - the mean of the A2 Stephensons they will replace and the existing 'N' class - and their annual fuel consumption as 970 tons of either Lithgow or pulverised brown coal. It is assumed that they would operate throughout the State within the limitations of existing turn-table capacities.

ECONOMIC SURVEY

Group No.3 - 100 'N' class (Contd.)

Appendix 7 - Tabulation 1 - has been prepared on these bases to show the annual fuel requirements of the group, both as black coal and pulverised brown coal burning units. It also shows the likely distribution of the two fuels and their cost as loaded into locomotive bunkers.

From this it will be seen that the conversion of this group would reduce our demand for black coal by 97,000 tons a year and show a saving in fuel cost of £81,900 per annum.

(ii) Comparison of all relevant charges

Tabulation 2 - Appendix 7 - shows a comparison of all the relevant charges involved in operating this group on Lithgow coal and pulverised brown coal respectively.

In this case the following savings would result irrespective of whether the survey were considered from a National or a Railway viewpoint, as no imported coal is involved and no subsidies would apply:-

Savings for group of 100 locomotives	- £8,500 per annum.
Savings per locomotive	- £85 " "
Savings per ton of pulverised brown coal consumed	- 1/9d.

Whilst the amount likely to be saved in this case is not great, it does show that without being involved in any financial loss, the Department could operate this group of locomotives on pulverised brown coal and partake of the associated benefits; instead of retaining them as grate-fired units with all the disabilities connected with black coal firing, viz:-
inadequate coal supplies of inferior quality, late running, manual firing, smoke, sparks, etc.

(iii) Total expenditure involved

In this case the total expenditure involved rises to £1,474,000. The increase over the figures applying to the 'X' and 'R' class groups is due to the greater number of locomotives involved, the wider distribution of the fuel - which necessitates more transport wagons - and the increased number of fuelling points at which loading facilities have to be provided.

Details of this cost are shown on Appendix 7 - Tabulation 3. All charges arising from this cost, however, have already been included in the survey.

11. Lines to be operated by the proposed pulverised brown coal locomotive

Appendix 8 shows the lines that would be operated by each of the three groups of locomotives included in the foregoing survey and the refuelling points applying to them.

As previously stated this is based on the following assumptions:-

(a) The prior electrification of the Melbourne-Traralgon and Melbourne-Geelong sections.
(b) That 'R' class locomotives will be permitted to run on lines now authorised for A2 engines.
(c) That the operation of 'N' class engines will be restricted to lines with turning facilities suitable for them.

PHYSICAL CHARACTERISTICS

LOCOMOTIVE 32 'X' - PULVERISED BROWN COAL FIRED

LOCOMOTIVE 30 'X' - GRATE FIRED

ITEM	32 'X' (P.B.C.fired)	30 'X' (Grate fired)
GENERAL		
Date built	1929	1929
Date of last "thorough" overhaul	1.7.49	30.8.49
ENGINE DATA		
Wheel arrangement	2.8.2	2.8.2
Coupled wheel diameter - nominal (ins.)	60	60
Cylinder diam. stroke - " (")	22 x 28	22 x 28
Tractive effort - at 85%		
Engine (lbs.)	39,360	39,360
Booster (lbs.)	9,000	9,000
Total (lbs.)	48,360	48,360
BOILER DATA		
Type of boiler and No.	All steel-1877	All steel-1874
Date constructed	17.1.44	8.1.43
Date of 1st retubing	1949	1949
Working pressure (lbs.per sq.in.)	205	205
Evaporation - (lbs./per hour)	36,690	36,690
Boiler percentage	98.8	98.8
Maximum barrel diam.-internal (ins.)	72 1/2	72 1/2
Distance between tube plates (ins.)	224	224
Flue - tubes		
Number	30	30
Diameter (ins.)	5 1/4	5 1/4
Boiler - tubes		
Number	145	145
Diameter (ins.)	2 1/4	2 1/4
Elements		
Diameter (ins.)	1 1/2	1 1/2
Length of return bend (ft.)	9	9
End of element from tube plate - fireside (ins.)	16 7/8	16 7/8
Heating surface (sq.ft.)		
Flues	770	770
Tubes	1,594	1,594
Syphons (2)	52	52
Combustion chamber	47	47
Remainder of firebox	152	152
Total firebox	251	251
Total evaporative	2,615	2,615
Elements	492	492

PHYSICAL CHARACTERISTICS (Contd.)

ITEM	32 'X' (P.B.C.fired)	30 'X' (Grate fired)
Inner firebox		
Height at front (ins.)	75 7/8	75 7/8
" " back (ins.)	62 1/8	62 1/8
Length at top (ins.)	80 7/16	80 7/16
" " bottom (ins.)	89 9/16	89 9/16
Width at top (ins.)	59	59
" " bottom (ins.)	67 3/8	67 3/8
Combustion chamber length (ins.)	29 3/4	29 3/4
Firebox volume - above 8" firebed, less syphons and brick-arch (cub.ft.)	-	197
Firebox volume - includes firebrick pan; but excludes syphons, arch tubes and brickwork	243	-
Detail:		
Combustion chamber	44	44
Remainder of firebox	199	153
Total	243	197
Grate		
Type	-	Shaker table
Length (ins.)	-	90 3/8
Breadth (ins.)	-	67 3/8
Area (sq.ft.)	-	42
Angle	-	7°-25'
Average air opening - overall (%)	-	26.5
" " " - drop-gate (%)	-	38.2
" " " - front (%)	-	29.6
" " " - rear (%)	-	21.8
Brick Arch		
Horiz.length to lower edge (ins.)	54 7/8	40 7/8
Angle from horizontal	19°-0'	32°-30'
Firedoor		
Type	Fixed (Special)	Franklin pneum.
Smokebox		
Smokebox dia. inside (ins.)	72	72
" length " (ins.)	69	69
Chimney choke dia. (ins.)	20	20
Equivalent blast pipe cap dia.(ins.)	6 1/16	6 1/4
Ratio - area under deflector plate to area through tubes (%)	70.5	70.5
TENDER CAPACITY		
Water (galls.)	6,600	8,660
Fuel (cwts.)	204	180
Fuel (cub.ft.)	766.5	-
PULVERISED BROWN COAL FIRING UNIT DETAILS		
Type & No. of unit	"Stug" combined drive No.3027	-
Turbine Speed - max. (r.p.m.)	4,200	-
Primary air supply - max. 2 fans (cub.ft. per hour)	332,000 (nom.) 337,000 (act.)	-
Gear ratio. Turbine-conveyor screws	29 to 1	-
Fuel feed - max., 2 screws (lbs.per hour)	4,850	-

APPENDIX 2.
(Sheet 1 of 3).

STANDING TEST RESULTS

COMPARISON OF YALLOURN PULVERISED BROWN COAL WITH MAITLAND AND LITHGOW LUMP BLACK COALS AS LOCOMOTIVE FUELS

Test No.	Gear ratio	Equiv-alent B.P.cap dia. (ins.)	FUEL												Ash fusion temp. (°F.)	Turbine speed (r.p.m.)	Steam press. (lb/sq.in)
			PROXIMATE ANALYSIS					SIEVE ANALYSIS									
			C.V. (B.T.U.)	Moist. (%)	V.M. (%)	F.C. (%)	Ash (%)	+ 36 (%)	+ 60 (%)	+120 (%)	+150 (%)	+240 (%)	+300 (%)	-300 (%)			
Loco. 32 'X' - Pulverised Brown Coal Fired (Fuel from Yallourn Briquetting Factory Drier Stack Precipitators)																	
ONE BURNER																	
2	29:1	6 1/4	10380	5.16	47.24	45.74	1.86									1260	202
3	"	"	10380	"	"	"	"									1900	200
4	"	"	10380	"	"	"	"									2710	199
1	"	"	10380	"	"	"	"									3700	195
TWO BURNERS								1.1	10.9	26.1	4.9	30.3	4.1	22.6			
5	29:1	6 1/4	10540	5.48	46.86	45.90	1.76									2490	199
6	"	"	"	"	"	"	"								2700 to	3020	198
10	"	"	"	"	"	"	"								2730	4120	200
13	"	"	10718	5.84	47.40	44.66	2.10									4530	201
14	"	6 1/8	"	"	"	"	"									4544	200
Loco. 30 'X' Grate Fired - Lithgow Coal (Mixed fields)																	
5A	-	6 1/4	11541	3.5	27.76	49.84	19.9	-	-	-	-	-	-	-	-	-	201
4A	-	"	"	"	"	"	"	-	-	-	-	-	-	-	-	-	192
1A	-	"	11290	3.74	27.44	48.86	19.96	-	-	-	-	-	-	-	-	-	201
3A	-	"	11025	3.26	25.98	49.20	21.56	-	-	-	-	-	-	-	-	-	199
Loco. 30 'X' Grate Fired - Maitland Coal (Mixed)																	
6B	-	6 1/4	13512	2.40	36.05	53.74	7.81	-	-	-	-	-	-	-	-	-	201
5B	-	"	"	"	"	"	"	-	-	-	-	-	-	-	-	-	203
2B	-	"	"	"	"	"	"	-	-	-	-	-	-	-	-	-	199
3B	-	"	"	"	"	"	"	-	-	-	-	-	-	-	-	-	200

STANDING TEST RESULTS

APPENDIX 2.
(Sheet 2 of 3).

COMPARISON OF YALLOURN PULVERISED BROWN COAL WITH MAITLAND AND LITHGOW LUMP BLACK COALS AS LOCOMOTIVE FUELS

Test No.	TEMPERATURES			AIR SUPPLY						DRAFT			Flue Gas
	F'box	S'box	S'heat steam	Primary	Secondary			Primary air pressure		S'box		F'box	
					Under arch	F'pan	F'hole	L.H. duct	R.H. duct	Front	Rear		
	(°F.)	(°F.)	(°F.)	(%)	(%)	(%)	(%)	(in.wg)	(in.wg)	(ins. wg)	(ins. wg)	(ins. wg)	CO2 (%)
32 'X' Pulverised Brown Coal Fired (Fuel from Yallourn Briquetting Factory Drier Stack Precipitators)													
ONE BURNER													
2	2420	437	-	26.4	59.1	14.5	-	0.8	2.0	1.35	1.06	0.85	6.4
3	2460	470	470	31.2	46.8	16.2	5.8	2.4	4.2	1.91	1.06	0.96	8.57
4	2610	515	608	36.0	47.3	10.6	6.1	7.0	7.0	2.12	1.29	0.96	11.6
1	2710	530	535	83.4	-	11.5	5.1	9.6	14.2	1.80	1.15	0.74	16.5
TWO BURNERS													
5	2580	602	640	35.3	47.8	10.7	6.2	4.1	4.3	3.44	2.33	1.70	13.7
6	2620	613	652	38.2	45.3	10.1	6.4	6.2	6.8	4.68	3.10	2.20	14.7
10	2680	646	660	43.7	39.4	11.2	5.7	11.1	12.1	8.20	5.18	3.36	12.6
13	2630	675	656	48.2	39.0	7.9	4.9	12.9	14.2	8.33	5.36	3.35	14.5
14	2630	670	655	46.0	40.3	8.7	5.0	12.8	14.2	9.03	6.02	3.98	13.5
30 'X' Grate Fired - Lithgow coal (Mixed fields)													
5A	2723	539	540	-	-	-	-	-	-	4.00	3.12	1.75	11.2
4A	2772	578	573	-	-	-	-	-	-	6.13	4.56	2.4	11.58
1A	2818	622	582	-	-	-	-	-	-	7.75	5.77	3.03	12.38
3A	2788	633	597	-	-	-	-	-	-	9.67	7.23	4.00	11.75
30 'X' Grate Fired - Maitland Coal (Mixed)													
6B	-	616	606	-	-	-	-	-	-	7.0	5.0	3.7	7.1
5B	-	625	615	-	-	-	-	-	-	8.7	5.9	3.9	12.1
2B	-	646	618	-	-	-	-	-	-	10.0	6.5	2.6	10.5
3B	-	648	589	-	-	-	-	-	-	10.0	6.6	3.0	10.8

STANDING TEST RESULTS

COMPARISON OF YALLOURN PULVERISED BROWN COAL WITH MAITLAND AND LITHGOW LUMP BLACK COALS AS LOCOMOTIVE FUELS

Test No.	EVAPORATION lbs per hr.	EVAPORATION lbs/lb. coal (actual)	EVAPORATION lbs/lb. coal (equiv.)	STEAM CONS. OF TURBINE lbs/hr.	STEAM CONS. OF TURBINE % of total evap.	Boiler effy. (incl. S'heat-er) (%)	Coal Cons. per hour Tot-al (lbs)	Coal Cons. per hour per sq.ft. grate (lbs)	F'box stress (B.T.U. /c.ft. /hr.)	Boi-ler H.P.	Coal cons/boi-ler H.P. hr. (lbs)	Degree of S'heat (°F.)	Evap. /sq.ft. htg. surface /hr. (lbs)	Ashpan Residue wt. (lbs /hr.)	Ashpan Residue Comb. mat'l. (%)
Loco. 32 'X' - Pulverised Brown Coal Fired (Fuel from Yallourn Briquetting Factory Drier Stack Precipitators)															
ONE BURNER															
2	4260	5.61	6.82	115	2.70	63.7	760	-	32450	205	3.71	-	1.63	-	-
3	6495	6.18	7.62	115	1.77	71.2	1050	-	44800	312	3.37	83	2.48	-	-
4	10950	6.76	8.66	487	4.45	81.0	1620	-	69100	526	3.07	-	4.18	-	-
1	14800	6.68	8.53	592	4.00	80.0	2218	-	94500	711	3.12	149	5.65	-	-
TWO BURNERS															
5	17750	6.25	8.25	260	1.46	75.8	2840	-	123200	853	3.32	252	6.78	-	-
6	21015	5.81	7.84	278	1.32	71.4	3620	-	157100	1010	3.58	264	8.04	-	-
10	27900	5.87	7.98	905	3.24	73.5	4750	-	206100	1340	3.54	272	10.65	-	-
13	30240 (max)	5.77	7.87	987	3.25	71.3	5250	-	232000	1455	3.61	269	11.55	-	-
14	29090	5.60	7.65	1000	3.44	69.3	5200	-	230000	1400	3.71	268	11.11	-	-
Loco. 30 'X' Grate Fired - Lithgow Coal (Mixed fields)															
5A	16317	6.35	8.28	-	-	69.6	2572	61.2	150800	796	3.23	152	6.24	640	35.8
4A	21955	5.88	7.80	-	-	65.5	3735	89	219000	1055	3.54	188	8.4	950	35.8
1A	23972	5.43	7.20	-	-	62.0	4412	105	253000	1150	3.84	194	9.18	970	36.9
3A	26463 (max)	5.07	6.78	-	-	59.6	5241	124	293500	1272	4.12	210	10.1	1160	36.9
Loco. 30 'X' Grate Fired - Maitland Coal (Mixed)															
6B	23500	7.38	9.78	-	-	70.3	3178	75.6	218000	1130	2.81	216	8.98	114	21.8 (6B–3B)
5B	27467	7.28	9.75	-	-	69.8	3780	90.0	260000	1322	2.86	226	10.51	136	
2B	29450	6.52	8.71	-	-	62.4	4592	109.4	315000	1417	3.24	229	11.28	150	
3B	31100 (max)	6.73	8.82	-	-	63.3	4624	110.0	317500	1494	3.1	201	11.9	150	

DYNAMOMETER CAR EFFICIENCY TEST RESULTS

COMPARISON OF YALLOURN PULVERISED BROWN COAL WITH MAITLAND, LITHGOW AND WONTHAGGI LUMP BLACK COALS AS LOCOMOTIVE FUELS

Test Section: Melbourne-Bendigo-Melbourne. Steaming Chart: X B/3

Test No.	Avg. Train Load (Round trip) Tons = Vehs.	Round Trip Times Yard to Yard: Overall (mins.)	Round Trip Times Yard to Yard: Running (mins.)	Locomotive Performance - Yard to Yard: Water Cons. (lbs.)	Coal Cons. (lbs.)	Work Units ($2x10^6$ ft.lbs)	Evap. Act. (lbs/lb.)	Evap. Equiv. (lbs/lb.)	Work Units per lb. coal ($2x10^6$ ft.lbs)	Avg. Boiler Press. (Chart Steaming Section only) (lbs/sq.in.)	Avg. Super Steam Temp (Chart Steaming Section only) °F.
PULVERISED BROWN COAL - Loco. 32 'X' (Blast Pipe-Equiv. 6 1/16" dia.)											
1645 & 6	655 = 46	576	472	141630	23080	4408	6.14	8.22	0.191	203	624
1633 & 4	650 = 41	565	487	141730	24040	4540	5.90	7.92	0.189	203	626
1637 & 8	652 = 40	562	479	141720	22754	4232	6.22	8.40	0.186	204	643
1685 & 6	649 = 31	529	449	141420	24050	4227	5.88	7.96	0.176	204	645
AVERAGES:	652 = 40	558	472	141625	23481	4352	6.04	8.12	0.186	203.5	635
MAITLAND LUMP BLACK COAL - Loco. 30 'X' (Blast Pipe-Equiv. 6 1/4" dia.)											
1652 & 3	654 = 50	532	479	144800	20232	4652	7.14	9.53	0.230	209	609
1656 & 7	649 = 36	544	474	136900	21014	4265	6.5	8.66	0.203	206	603
1655 & 8	651 = 32	501	445	133020	18980	4116	7.01	9.30	0.217	208	606
1668 & 9	649 = 34	534	450	131150	19073	4419	6.88	9.23	0.231	205	626
AVERAGES:	651 = 38	528	462	136467	19825	4363	6.88	9.18	0.220	207	611
LITHGOW LUMP BLACK COAL - Loco. 30 'X' (Blast Pipe-Equiv. 6 1/4" dia.)											
1619 & 22	654 = 34	568	491	140760	24537	4855	5.74	7.75	0.198	203	611
1641 & 2	652 = 40	641	517	143290	24838	4250	5.76	7.71	0.171	201	611
1643 & 4	650 = 42	686	515	150300	24997	4332	6.01	8.05	0.173	202	615
1647 & 8	652 = 39	596	482	118400	23897	4334	5.55	7.45	0.181	201	612
AVERAGES:	652 = 39	623	501	143185	24615	4443	5.77	7.74	0.180	202	612
WONTHAGGI LUMP BLACK COAL - Loco. 30 'X' (Blast pipe-Equiv. 6 1/4" dia.)											
1708 & 09	648 = 32	563	518	132920	23048	4222	5.76	7.72	0.183	204	591
1712 & 13	649 = 36	586	504	145370	24993	4625	5.82	7.95	0.185	204	637
1704 & 05	648 = 34	581	490	142770	26680	4412	5.35	7.20	0.165	200	600
1706 & 07	654 = 31	600	500	152370	28158	4323	5.41	7.26	0.154	200	590
AVERAGES:	649 = 33	582	503	143357	25720	4395	5.59	7.53	0.172	202	605

DYNAMOMETER CAR EFFICIENCY TEST RESULTS

APPENDIX 3.
(Sheet 2 of 2).

COMPARISON OF YALLOURN PULVERISED BROWN COAL WITH MAITLAND, LITHGOW AND WONTHAGGI LUMP BLACK COALS AS LOCOMOTIVE FUELS

Test Section: Melbourne-Bendigo-Melbourne. Steaming Chart: X B/3

Test No.	FUEL												Ashpan Residue (lbs.)
	PROXIMATE ANALYSIS					SIEVE ANALYSIS							
	C.V. (B.T.U.)	Moist. (%)	V.M. (%)	F.C. (%)	Ash. (%)	+ 36 (%)	+ 60 (%)	+120 (%)	+150 (%)	+240 (%)	+300 (%)	-300 (%)	
PULVERISED BROWN COAL - Loco. 32 'X' (Blast Pipe-Equiv. 6 1/16" dia.)													
1645 & 6	10468	6.02	46.02	45.92	2.04								Nil
1633 & 4	10420	5.22	46.28	46.42	2.08	1.1	10.9	26.1	4.9	30.3	4.1	22.6	Nil
1637 & 8	10565	5.50	45.86	47.06	1.58								Nil
1685 & 6	10345	5.56	45.48	47.90	2.06								Nil
AVERAGES:	10425	5.56	45.91	46.83	1.94								
MAITLAND LUMP BLACK COAL - Loco. 30 'X' (Blast Pipe-Equiv. 6 1/4" dia.)													
1652 & 3	13490	2.24	36.08	52.66	9.02	-	-	-	-	-	-	-	910
1656 & 7	13490	2.24	36.08	52.66	9.02	-	-	-	-	-	-	-	770
1655 & 8	13553	2.17	36.32	52.77	8.74	-	-	-	-	-	-	-	700
1668 & 9	13679	2.20	38.25	51.94	7.61	-	-	-	-	-	-	-	770
AVERAGES:	13553	2.21	36.68	52.51	8.60	-	-	-	-	-	-	-	788
LITHGOW LUMP BLACK COAL - Loco. 30 'X' (Blast Pipe-Equiv. 6 1/4" dia.)													
1619 & 22	11589	3.10	27.80	55.74	18.28	-	-	-	-	-	-	-	3450
1641 & 2	11456	2.54	26.46	51.78	19.22	-	-	-	-	-	-	-	3850
1643 & 4	11456	2.54	26.46	51.78	19.22	-	-	-	-	-	-	-	3500
1647 & 8	11456	2.54	26.46	51.78	19.22	-	-	-	-	-	-	-	3500
AVERAGES:	11489	2.68	26.79	52.77	18.98	-	-	-	-	-	-	-	3575
WONTHAGGI LUMP BLACK COAL - Loco. 30 'X' (Blast Pipe-Equiv. 6 1/4" dia.)													
1708 & 09	11420	8.26	27.80	51.24	12.70	Dudley Area Coal.			-	-	-	-	1260
1712 & 13	11609	5.42	27.98	51.66	14.94	-	-	-	-	-	-	-	1500
1704 & 05	10543	8.76	27.54	47.22	16.48	Western Area Coal.			-	-	-	-	3220
1706 & 07	10556	8.76	27.78	47.02	16.44	-	-	-	-	-	-	-	3430
AVERAGES:	11032	7.80	27.78	49.27	15.14								2350

COST OF LOCOMOTIVE COALS LOADED INTO LOCOMOTIVE BUNKERS AT PRINCIPAL REFUELLING POINTS
(Including all charges as indicated below).

Class of Coal	Pulverised Brown Coal		Black Coal (local)			Black Coal (imported)		
			Lithgow	State Mine	Maitland	Average	Sth. African	Indian
Basic cost-per ton	30/- f.o.r. Yallourn	37/6 f.o.r. Morwell	63/6 f.o.r. Wodonga 66/- f.o.r. Tocumwal	55/- f.o.r. Wonthaggi	75/- f.o.r. Melbourne or Geelong	£6.7.0 f.o.r. Melbourne or Geelong	£6.9.4 f.o.r. Melbourne or Geelong	£6.4.8 f.o.r. Melbourne or Geelong
Transport charge-pence per ton-mile	2.34	2.34	1.33	1.33	1.33	1.33	1.33	1.33
Handling and Storage charge-per ton	(1) 3/6	(1) 3/6	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual
	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
North Melbourne	2.10. 1	2.17. 7	4. 6. 7	3. 6.10	3.17. 4	6. 9. 4	6.11. 8	6. 7. 0
Bendigo	3. 9. 7	3.17. 1	4. 6.11	4. 0. 0	4.10. 5	7. 2. 5	7. 4. 9	7. 0. 1
Woodend	2.19. 8	3. 7. 2	4.12. 8	3.14. 3	4. 4. 8	6.16. 8	6.19. 0	6.14. 4
Korong Vale	3.19. 8	4. 7. 2	4.12. 5	4. 5. 6	4.16. 0	7. 8. 0	7.10. 4	7. 5. 8
Ultima	4.13. 4	5. 0.10	5. 0. 3	4.13. 3	5. 3. 9	7.15. 9	7.18. 1	7.13. 5
Kerang	4. 5. 2	4.12. 8	4.15. 7	4. 8. 9	4.19. 3	7.11. 3	7.13. 7	7. 8.11
Swan Hill	4.12. 0	4.19. 6	4.19. 6	4.12. 7	5. 3. 1	7.15. 1	7.17. 5	7.12. 9
Wycheproof	4. 7. 1	4.14. 7	4.16.10	4. 9.10	5. 0. 3	7.12. 3	7.14. 7	7. 9.11
Echuca	3.18. 4	4. 5.10	4. 0. 9	4. 4.10	4.15. 3	7. 7. 3	7. 9. 7	7. 4.11
Maryborough	3.11.11	3.19. 5	4.13. 3	4. 1. 3	4.11. 8	7. 3. 8	7. 6. 0	7. 1. 4
Donald	4. 5. 7	4.13. 1	5. 1. 1	4. 9. 1	4.19. 7	7.11. 7	7.13.11	7. 9. 3
Woomelang	4.17. 1	5. 4. 7	5. 7. 7	4.15. 6	5. 5.11	7.17.11	8. 0. 3	7.15. 7
Mildura	5.18. 5	6. 5.11	5.19. 9	5. 7. 8	5.18. 3	8.10. 3	8.12. 7	8. 7.11
Ouyen	5. 6. 6	5.14. 0	5.12.11	5. 0.10	5.11. 3	8. 3. 3	8. 5. 7	8. 0.11
Geelong	2.18.11	3. 6. 4	4.13. 6	3.13. 9	3.19. 3	6.11. 3	6.13. 7	6. 8.11
Camperdown	3.14. 3	4. 1. 9	5. 2. 1	4. 2. 5	4. 8. 0	7. 0. 0	7. 2. 4	6.17. 8
Warrnambool	4. 2. 3	4. 9. 9	5. 6.11	4. 7. 3	4.12. 8	7. 4. 8	7. 7. 0	7. 2. 4
Ballarat East	3. 4. 4	3.11.10	4.16. 7	3.16.11	4. 4. 4	6.16. 4	6.18. 8	6.14. 0
Ararat	3.15. 7	4. 3. 1	5. 1. 1	4. 1. 4	4. 8.10	7. 0.10	7. 3. 2	6.18. 6

Note:- (1) For the group of 100 - N class locomotives, this rate increases to 4/-.

COST OF LOCOMCTIVE COALS LOADED INTO LOCOMOTIVE BUNKERS AT PRINCIPAL REFUELLING POINTS
(Including all charges as indicated below).

Class of Coal	Pulverised Brown Coal		Black Coal (local)			Black Coal (imported)		
			Lithgow	State Mine	Maitland	Average	Sth.African	Indian
Basic cost-per ton	30/- f.o.r. Yallourn	37/6 f.o.r. Morwell	63/6 f.o.r. Wodonga 66/- f.o.r. Tocumwal	55/- f.o.r. Wonthaggi	75/- f.o.r. Melbourne or Geelong	£6.7.0 f.o.r. Melbourne or Geelong	£6.9.4 f.o.r. Melbourne or Geelong	£6.4.8 f.o.r. Melbourne or Geelong
Transport charge-pence per ton-mile	2.34	2.34	1.33	1.33	1.33	1.33	1.33	1.33
Handling and Storage charge-per ton	(1) 3/6	(1) 3/6	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual	2/4 mechanical 4/3 manual
	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
Hamilton	4. 8. 6	4.16. 0	5.10. 5	4.10. 9	4.18. 3	7.10. 3	7.12. 7	7. 7.11
Murtoa	4. 6. 2	4.13. 8	5. 9. 0	4. 9. 3	4.16. 9	7. 8. 9	7.11. 1	7. 6. 5
Dimboola	4.13. 9	5. 1. 3	5.13. 5	4.13. 9	5. 1. 3	7.13. 3	7.15. 7	7.10.11
Serviceton	5. 6. 0	5.13. 6	6. 0. 3	5. 0. 7	5. 8. 1	8. 0. 1	8. 2. 5	7.17. 9
Warracknabeal	4.12. 2	4.19. 8	5.12. 7	4.12.10	5. 0. 3	7.12. 3	7.14. 7	7. 9.11
Seymour	3. 1.11	3. 9. 5	4. 1. 9	3.15. 7	4. 6. 0	6.18. 0	7. 0. 4	6.15. 8
Shepparton	3.12. 1	3.19. 7	3.15. 0	4. 1. 4	4.11. 9	7. 3. 9	7. 6. 1	7. 1. 5
Numurkah	3.16. 0	4. 3. 6	3.12.10	4. 3. 7	4.14. 1	7. 6. 1	7. 8. 5	7. 3. 9
Benalla	3.13. 8	4. 1. 2	3.15. 1	4. 2. 2	4.12. 8	7. 4. 8	7. 7. 0	7. 2. 4
Wangaratta	3.18. 5	4. 5.11	3.12. 5	4. 4.11	4.15. 5	7. 7. 5	7. 9. 9	7. 5. 1
Wodonga	4. 6. 6	4.14. 0	3. 5.10	4. 7. 7	4.18. 1	7.10. 1	7.12. 5	7. 7. 9
Yallourn	1.13. 9	2. 1. 3	4.18. 3	3.14. 5	4. 9. 0	7. 1. 0	7. 3. 4	6.18. 8
Traralgon	1.16. 5	2. 3.11	4.19. 4	3.15. 6	4.10. 3	7. 2. 3	7. 4. 7	6.19.11
Warragul	1.18. 3	2. 5. 9	4.15. 3	3.11. 7	4. 7. 0	6.19. 0	7. 1. 4	6.16. 8
Bairnsdale	2.11. 3	2.18. 9	5. 7. 6	4. 3. 7	4.18. 3	7.10. 3	7.12. 7	7. 7.11
Sale	2. 2. 3	2. 9. 9	5. 2. 9	3.18.11	4.13. 5	7. 5. 5	7. 7. 9	7. 3. 1
Yarram	3. 9. 5	3.16.11	5. 3. 7	3.11. 7	4.14. 3	7. 6. 3	7. 8. 7	7. 3.11
Korrumburra	2.16. 4	3. 3.10	4.16. 2	3. 4.11	4. 6.11	6.18.11	7. 1. 3	6.16. 7
State Mine	2.19.10	3. 7. 4	4.18. 0	2.15. 0	4. 8.10	7. 0.10	7. 3. 2	6.18. 6

Note:- (1) For the group of 100 - N class locomotives, this rate increases to 4/-.

APPENDIX 5.
TABULATION 1.

COMPARATIVE FUEL COSTS FOR 44 'X' CLASS LOCOMOTIVES (29 EXISTING, 15 NEW) WHEN FIRED WITH LUMP BLACK AND PULVERISED BROWN COALS - ANNUAL MILEAGE 33,000 PER LOCOMOTIVE

BASED ON ANTICIPATED SUPPLIES AND DISTRIBUTION FOR 1950-1 (= 90% IMPORTED)

Refuelling Point	Annual requirements of Black Coal						Annual requirement of pulverised Brown Coal	
	Lithgow @ 66/- per ton f.o.r. Tocumwal or 63/6 per ton f.o.r. Wodonga		Wonthaggi @ 55/- per ton f.o.r. Wonthaggi		Imported @ £6.7.0 per ton f.o.r. Melbourne or Geelong		50%-30/- ton f.o.r. Yallourn 50%-37/6 ton f.o.r. Morwell	
	(tons)	Cost incl. transport & handling (£)	(tons)	Cost incl. transport & handling (£)	(tons)	Cost incl. transport & handling (£)	(tons)	Cost incl. transport & handling (£)
North Melbourne	-	-	4,800	16,050	41,500	272,000	46,300	124,500
Bendigo	-	-	-	-	10,890	77,500	10,890	40,000
Ararat	-	-	-	-	4,830	34,000	4,830	19,200
Seymour	-	-	-	-	3,950	27,300	3,950	12,900
Maryborough	-	-	-	-	3,170	22,800	3,170	12,000
Korong Vale	-	-	-	-	2,910	21,600	2,910	12,100
Wodonga	2,280	7,500	-	-	-	-	2,280	10,300
Geelong	-	-	-	-	1,980	13,000	1,980	6,200
Benalla	1,280	4,800	-	-	900	6,500	2,180	8,400
Dimboola	-	-	-	-	2,080	15,900	2,080	10,100
Donald	-	-	390	1,740	820	6,200	1,210	5,400
Ballarat	-	-	-	-	610	4,200	610	2,100
Serviceton	-	-	-	-	610	4,900	610	3,400
Totals:-	3,560	12,300	5,190	17,790	74,250	505,900	83,000	266,600

Total fuel costs involved - Black Coal £535,990 per annum. Pulverised Brown Coal £266,600 per annum.

COMPARATIVE COSTS OF OPERATING 44 'X' CLASS LOCOMOTIVES ON LUMP BLACK COAL AND PULVERISED BROWN COAL

Based on 90% imported Black Coal (= 1950-1 supply).

Annual mileage per loco - 33,000
Annual fuel consumption per loco - 2,000 tons existing locos.
1,700 tons new.

Item	Black coal firing (£)	Pulverised brown coal firing (£)
FIXED CHARGES. (See para. 3) Nett pulverised brown coal firing equipment and loco. conversion cost for 43 locos.at £8,200 each. Interest at 3 1/4% Depreciation at 4% & 7 1/2% R.V.	- 	352,000 11,500 13,000
MAINTENANCE CHARGE. (See para. 4) Added maintenance of pulverised brown coal locos. at 4 pence per mile	-	24,200
FUEL COSTS. (See Tabulation 1) Total annual cost for black coal loaded into loco. bunkers Total annual cost for pulverised brown coal loaded into loco. bunkers:- 50% at 30/- per ton for.Yallourn 50% at 37/6 " " " Morwell	536,000	266,600
ASH HANDLING & DISPOSAL COSTS. (See para. 7) Total cost for 44 locos. at 20 pence per ton of coal consumed	6,900	
TOTALS:	542,900	315,300

NETT ANNUAL CREDIT TO PULVERISED BROWN COAL FIRING

Item	Credit to pulverised brown coal firing
For group of 44 locomotives	£227,600
Per locomotive	£5,170
Per ton of pulverised brown coal consumed	£2.14.0

APPENDIX 5.
TABULATION 3.

PULVERISED BROWN COAL FIRING OF 44 'X' CLASS LOCOMOTIVES

TOTAL EXPENDITURE INVOLVED

Item	Unit Cost (£)	Total Cost (£)
Conversion of 28 existing locomotives (1-unit already converted)	9,200	258,000
Additional cost of 15 new pulverised brown coal locomotives, above that of standard units (Work to be carried out by Clyde Engineering Co.)	8,500	127,000
Construction of 200 'CK' wagons	1,400	280,000
Provision of 10 overhead fuel storage hoppers at the following locations:-		86,000
252 ton hopper - Nth.Melbourne	30,000	
112 " " - Bendigo	13,500	
56 " hoppers - Ararat	7,000	
Seymour	"	
Maryborough	"	
Korong Vale	"	
28 " " - Wodonga	3,500	
Benalla	"	
Dimboola	"	
Geelong	"	
Provision of facilities for refuelling from 'CK' wagons at:- Donald	200	
Ballarat	"	
Serviceton	"	
Provision of emergency briquette storage, pulverising plant and pulverised brown coal hopper storage at North Melbourne	50,000	50,000
Total expenditure involved		801,000
plus 10% contingency for rising prices, spares, etc.		80,000
GRAND TOTAL	=	881,000

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Credits arising from the conversion of 28 existing locomotives @ £1,200 each — £33,000

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THE ABOVE COST FOR 'CK' WAGON CONSTRUCTION IS BASED ON NEWPORT MANUFACTURE. IF THIS WORK WERE CARRIED OUT BY AN OUTSIDE CONTRACTOR, THE UNIT RATE FOR THIS ITEM WOULD PROBABLY RISE TO ABOUT £2,600.

APPENDIX 6.
TABULATION 1.

COMPARATIVE FUEL COSTS FOR 70 'R' CLASS LOCOMOTIVES

WHEN FIRED WITH LUMP BLACK COAL AND PULVERISED BROWN COALS,

- ANNUAL MILEAGE - 37,000 PER LOCOMOTIVE

BASED ON SOUTH AFRICAN COAL AND PRIOR
ELECTRIFICATION OF MELBOURNE-TRARALGON
AND MELBOURNE-GEELONG SECTIONS.

1.05 tons pulverised brown coal equivalent to 1 ton South African coal.

Refuelling Points	Annual requirement of Black Coal		Annual requirement of Pulverised Brown Coal	
	Imported @ £6.9.4 per ton f.o.r. Melbourne or Geelong		@ 37/6 per ton f.o.r. Morwell	
	(tons)	Cost including transport and handling (£)	(tons)	Cost including transport and handling (£)
North Melbourne	25,900	170,500	27,000	77,700
Bendigo	3,200	23,100	3,400	13,130
Seymour	1,400	9,800	1,500	5,230
Benalla	2,700	19,800	2,900	11,760
Wodonga	1,400	10,700	1,500	7,030
Ballarat East	6,000	41,600	6,300	22,630
Maryborough	3,700	27,000	3,900	15,480
Donald	2,200	16,900	2,300	10,750
Ouyen	2,700	22,400	2,800	15,960
Mildura	3,100	26,700	3,200	20,170
Ararat	19,200	137,500	20,000	83,100
Dimboola	5,100	39,700	5,350	27,100
Serviceton	1,100	8,900	1,100	6,220
Geelong	8,500	56,800	8,950	29,700
Warrnambool	1,800	13,200	1,800	8,040
Hamilton	1,800	13,700	1,800	8,640
Traralgon	1,300	9,400	1,400	3,230
Bairnsdale	700	5,300	700	2,010
Korrumburra	1,100	7,800	1,100	3,520
TOTALS:	93,000	660,800	97,000	371,400

Total fuel costs - Sth. African Coal = £660,800 per annum.
Pulverised Brown Coal = £371,400 " "

Savings for Pulverised Brown Coal = £289,400 per annum.

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COMPARATIVE COSTS OF OPERATING 70 'R' CLASS LOCOMOTIVES ON SOUTH AFRICAN BLACK COAL AND PULVERISED BROWN COAL

Annual mileage per loco = 37,000.
Annual fuel consumption per loco:-
South African coal = 1,320 tons.
Pulverised brown coal = 1,380 tons.

Item	Black coal firing (£)	Pulverised brown coal firing (£)
FIXED CHARGES. (See para. 3) Nett pulverised brown coal firing equipment and loco. conversion cost for 70 locos.at £8,200 each		574,000
Interest at 3 1/4%		18,700
Depreciation at 4% & 7 1/2% R.V.		21,200
MAINTENANCE CHARGE. (See para. 4) Added maintenance of pulverised brown coal locos. at 3 pence per mile		32,400
FUEL COSTS. (See Tabulation 1) Total annual cost for Sth.African coal loaded into loco. bunkers	660,800	
Total annual cost for pulverised brown coal loaded into loco. bunkers		371,400
ASH HANDLING & DISPOSAL COSTS. (See para. 7) Total cost for 70 locos. at 20 pence per ton of coal consumed	7,700	
TOTALS:	668,500	443,700

NETT ANNUAL CREDIT TO PULVERISED BROWN COAL FIRING

Item	Credit to pulverised brown coal firing
For group of 70 locomotives	£224,800
Per locomotive	£3,210
Per ton of pulverised brown coal consumed	£2.6.6

APPENDIX 6.
TABULATION 3.

PULVERISED BROWN COAL FIRING OF 70 'R' CLASS LOCOMOTIVES

TOTAL EXPENDITURE INVOLVED

Items	Unit Cost (£)	Total Cost (£)
Conversion of 70 locomotives	9,100	637,000
Construction of 240 'CK' wagons	1,400	336,000
Provision of 17 overhead fuel storage hoppers at the following locations:-		150,900
224 ton hopper - Ararat	28,000	
168 " " - Nth.Melbourne	21,000	
112 " hoppers - Ballarat East	14,000	
" " Geelong	"	
84 " " - Dimboola	10,500	
56 " " - Benalla	7,000	
Maryborough	"	
Donald	"	
Ouyen	"	
Mildura	"	
Bendigo	"	
28 ton hoppers - Seymour	3,500	
Wodonga	"	
Serviceton	"	
Warrnambool	"	
Hamilton	"	
Traralgon	"	
Provision of facilities for refuelling from 'CK' wagons at Bairnsdale	200	
Korumburra	"	
Contribution towards emergency briquette storage, pulverising plant and hopper storage at North Melbourne	38,000	38,000
		£1,161,900
Total expenditure involved plus 10% contingency for rising prices, spares, etc.	=	116,100
GRAND TOTAL	=	£1,278,000

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Credits arising from the conversion of 70 'R' class locomotives @ £1,000	=	£70,000

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THE ABOVE COST FOR 'CK' WAGON CONSTRUCTION IS BASED ON NEWPORT MANUFACTURE. IF THIS WORK WERE CARRIED OUT BY AN OUTSIDE CONTRACTOR, THE UNIT RATE FOR THIS ITEM WOULD PROBABLY RISE TO ABOUT £2,600.

APPENDIX 7.
TABULATION 1.

COMPARATIVE FUEL COSTS FOR 100 'N' CLASS LOCOMOTIVES WHEN FIRED WITH LUMP BLACK COAL AND PULVERISED BROWN COAL

Based on Lithgow Coal and prior electrification of Melbourne-Traralgon and Melbourne-Geelong Sections

1 ton of pulverised brown coal equivalent to 1 ton of Lithgow coal.

Annual mileage = 23,000 per locomotive.

Refuelling Points	Annual requirement of Lithgow coal @ 63/6 ton f.o.r. Wodonga and 66/- ton f.o.r. Tocumwal		Annual requirement of Pulverised Brown Coal @ 37/6 per ton f.o.r. Morwell	
	(tons)	Cost including transport and handling (£)	(tons)	Cost including transport and handling (£)
North Melbourne	28,000	121,000	28,000	81,300
Lilydale	1,000	4,400	1,000	3,200
Korumburra	3,000	14,400	3,000	9,700
Woodend	500	2,300	500	1,700
Wallan	500	2,100	500	1,600
Bendigo	2,000	8,700	2,000	7,700
Echuca	1,000	4,000	1,000	4,300
Moulamein	500	2,300	500	2,600
Korong Vale	1,000	4,600	1,000	4,400
Quambatook	500	2,400	500	2,400
Kerang	500	2,400	500	2,300
Seymour	3,500	14,300	3,500	12,200
Tocumwal	1,000	3,500	1,000	4,400
Benalla	4,000	15,000	4,000	16,300
Wodonga	2,500	8,200	2,500	11,800
Ballarat East	6,500	31,400	6,500	23,500
Maryborough	8,250	38,400	8,250	33,000
Donald	2,500	12,600	2,500	11,700
Woomelang	1,500	8,100	1,500	8,900
Ouyen	2,000	11,300	2,000	11,500
Murrayville	250	1,500	250	1,600
Mildura	2,000	12,000	2,000	12,600
Ararat	6,000	30,400	6,000	25,100
Murtoa	2,000	10,900	2,000	9,400
Dimboola	3,000	17,000	3,000	15,300
Serviceton	1,000	6,000	1,000	5,700
Hamilton	2,000	11,000	2,000	9,700
Heywood	1,000	5,700	1,000	5,200
Geelong	3,000	14,000	3,000	10,000
Colac	1,000	4,900	1,000	3,900
Warrnambool	1,500	8,000	1,500	6,800
Derrinallum	1,000	5,000	1,000	4,000
Traralgon	2,000	9,900	2,000	4,400
Bairnsdale	1,000	5,400	1,000	3,000
T O T A L S :	97,000	453,100	97,000	371,200

Total fuel costs - Lithgow coal £453,100 per annum.
Pulverised brown coal £371,200 " "

Savings for pulverised brown coal = £ 81,900 per annum.

COMPARATIVE COSTS OF OPERATING 100 'N' CLASS LOCOMOTIVES

ON LITHGOW BLACK COAL AND PULVERISED BROWN COAL

Annual mileage per loco = 23,000.
Annual fuel consumption per loco:-
Lithgow coal = 975 tons.
Pulverised brown coal = 975 tons.

Item	Black coal firing (£)	Pulverised brown coal firing (£)
FIXED CHARGES. (See para. 3) Nett pulverised brown coal firing equipment and loco. conversion cost for 100 locos. at £7,600 Interest at 3 1/4% Depreciation at 4% & 7 1/2% R.V.		760,000 24,700 28,100
MAINTENANCE CHARGE. (See para. 4) Added maintenance of pulverised brown coal locos. at 3 pence per mile		28,700
FUEL COSTS. (See Tabulation 1) Total annual cost for Lithgow coal loaded into locomotive bunkers Total annual cost for pulverised brown coal loaded into loco. bunkers	453,100	 371,200
ASH HANDLING AND DISPOSAL COSTS. (See para. 7) Total cost for 100 locos. at 20 pence per ton of coal consumed	8,100	
TOTALS:	461,200	452,700

NETT ANNUAL CREDIT TO PULVERISED BROWN COAL FIRING

Item	Credit to pulverised brown coal firing
For group of 100 locomotives	£8,500
Per locomotive	£85
Per ton of pulverised brown coal consumed	1/9d.

APPENDIX 7.
TABULATION 3.

PULVERISED BROWN COAL FIRING OF 100 'N' CLASS LOCOMOTIVES

TOTAL EXPENDITURE INVOLVED

Item		Unit Cost (£)	Total Cost (£)
Conversion of 100 locomotives		7,900	790,000
Construction of 260 CK wagons		1,400	364,000
Provision of 22 overhead fuel storage hoppers at the following locations:			139,000
168 ton hopper	- Nth.Melbourne	21,000	
112 " "	- Maryborough	14,000	
84 " hoppers	- Ballarat East	10,500	
	Ararat	"	
56 " "	- Korumburra	7,000	
	Bendigo	"	
	Seymour	"	
	Benalla	"	
	Dimboola	"	
	Geelong	"	
28 ton hoppers	- Wodonga	3,500	
	Donald	"	
	Woomelang	"	
	Ouyen	"	
	Mildura	"	
	Murtoa	"	
	Serviceton	"	
	Hamilton	"	
	Warrnambool	"	
	Traralgon	"	
	Bairnsdale	"	
Provision of facilities for refuelling from CK wagons at:-	Lilydale	200	
	Woodend	"	
	Wallan	"	
	Echuca	"	
	Moulamein	"	
	Quambatook	"	
	Kerang	"	
	Tocumwal	"	
	Murrayville	"	
	Heywood	"	
	Colac	"	
	Derrinallum	"	
Contribution towards emergency briquette storage, pulverising plant and hopper storage at Nth.Melbourne		47,000	47,000
Total expenditure involved			£1,340,000
plus 10% contingency for rising prices, spares, etc.			134,000
GRAND TOTAL			£1,474,000

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Credits arising from conversion of 100 'N' class locos.
@ £300 = £30,000.

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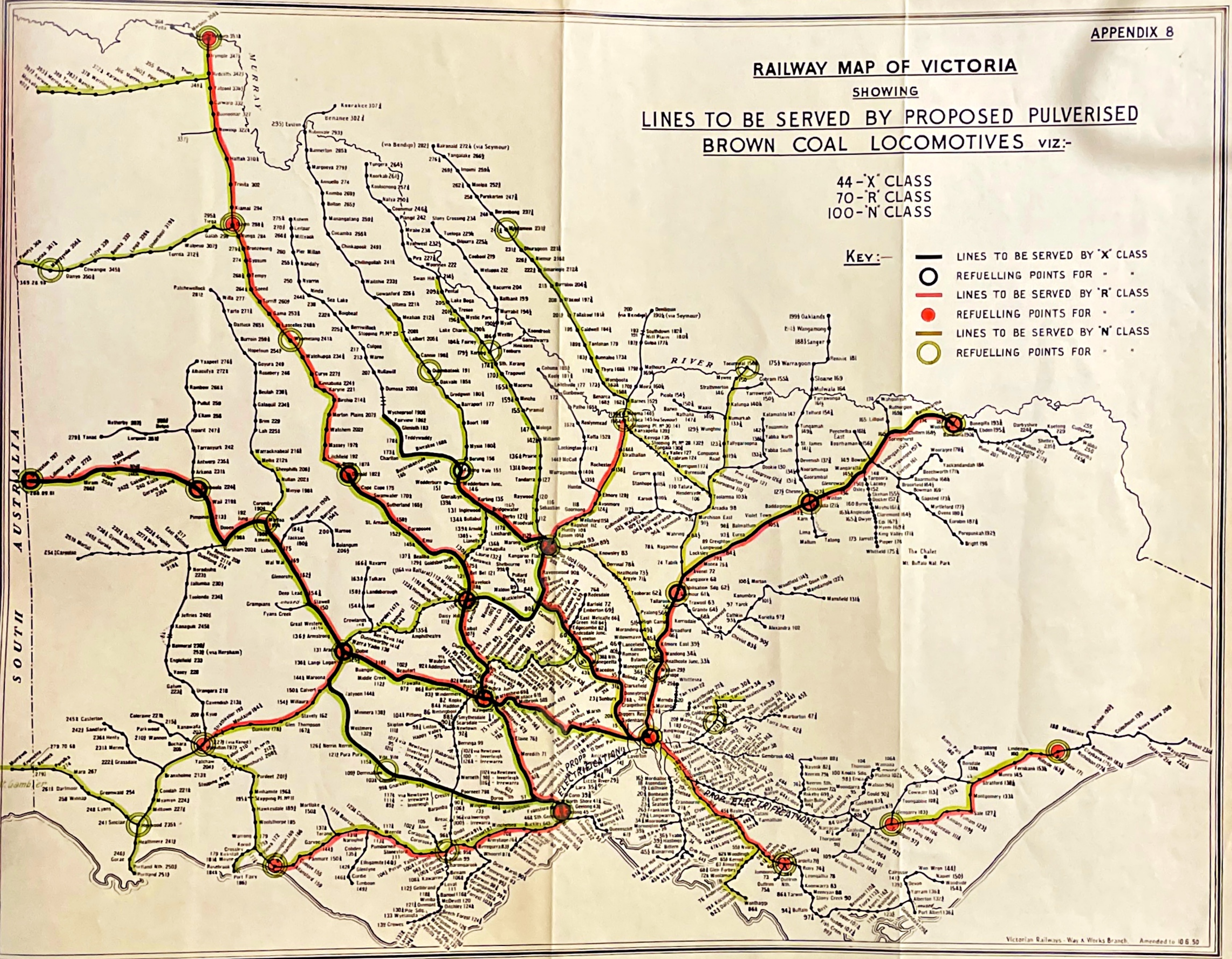
THE ABOVE COST FOR 'CK' WAGON CONSTRUCTION IS BASED ON NEWPORT MANUFACTURE. IF THIS WORK WERE CARRIED OUT BY AN OUTSIDE CONTRACTOR, THE UNIT RATE FOR THIS ITEM WOULD PROBABLY RISE TO ABOUT £2,600.


APPENDIX 8
RAILWAY MAP OF VICTORIA
SHOWING
LINES TO BE SERVED BY PROPOSED PULVERISED
BROWN COAL LOCOMOTIVES VIZ:-
44-"X" CLASS
70-"R" CLASS
100-"N" CLASS
KEY:-
LINES TO BE SERVED BY "X" CLASS
REFUELLING POINTS FOR " "
LINES TO BE SERVED BY "R" CLASS
REFUELLING POINTS FOR " "
LINES TO BE SERVED BY "N" CLASS
REFUELLING POINTS FOR " "
MURRAY
RIVER
SOUTH AUSTRALIA
PROP. ELECTRIFICATION
PROP. ELECTRIFICATION
To Mt. Gambier
Victorian Railways - Way & Works Branch. Amended to 10.6.50