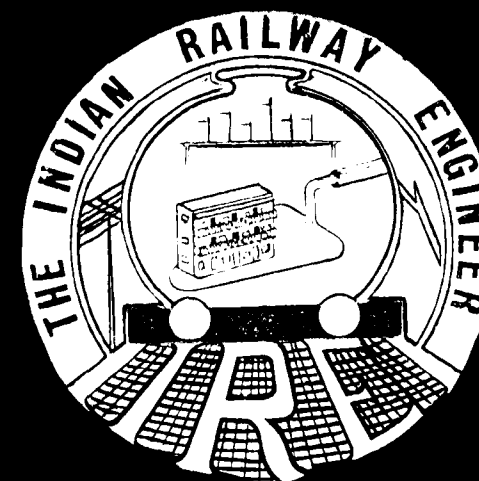


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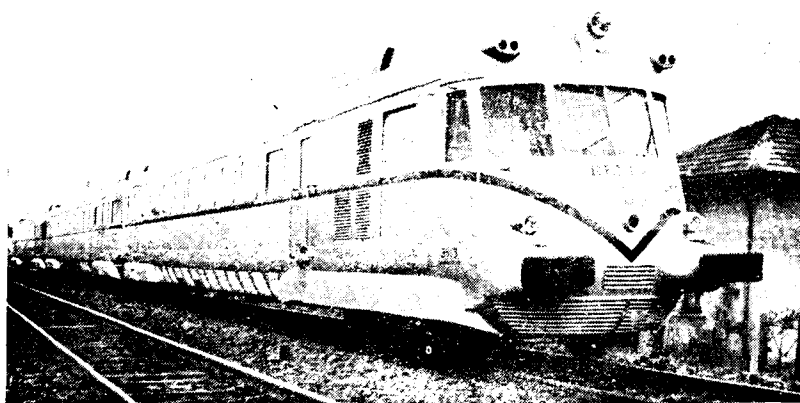
Managing Editor

T. S. N. Rao

Advertisement Manager

B. Amruta

FIAT DIESEL TRAIN SETS



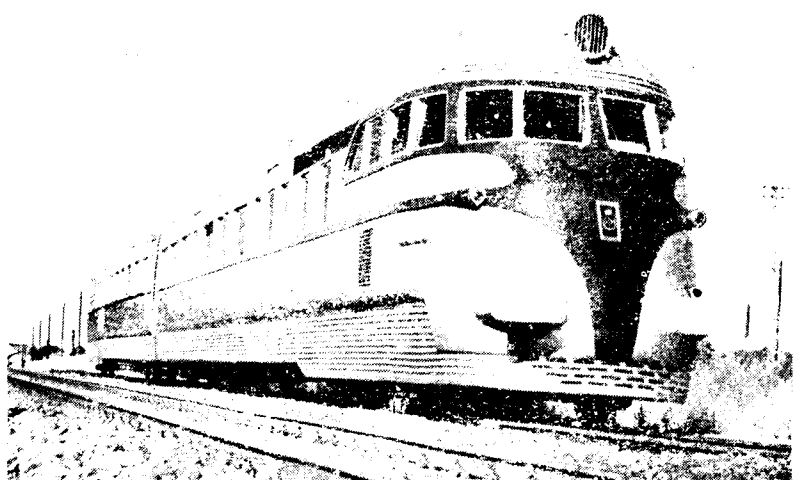
Diesel train set composed of power car + trailer + power car — Two 12-cyl. horizontal engines of 505 h. p. each — Seats for 174 passengers — Speed 75 m. p. h. — Bar and kitchen — Conditioned air.

Diesel train sets as supplied to the RENFE (Spanish) and CP (Portuguese) railways



92703

Diesel Saloon set for the Egyptian State Railways.



Diesel train set composed of power car and one trailer — Two 12-cyl. horizontal engines of 480 h. p. each — Conditioned air — Bedroom, Sitting room, bathroom, kitchens, telephones, radio — Top speed 75 m. p. h.

2215

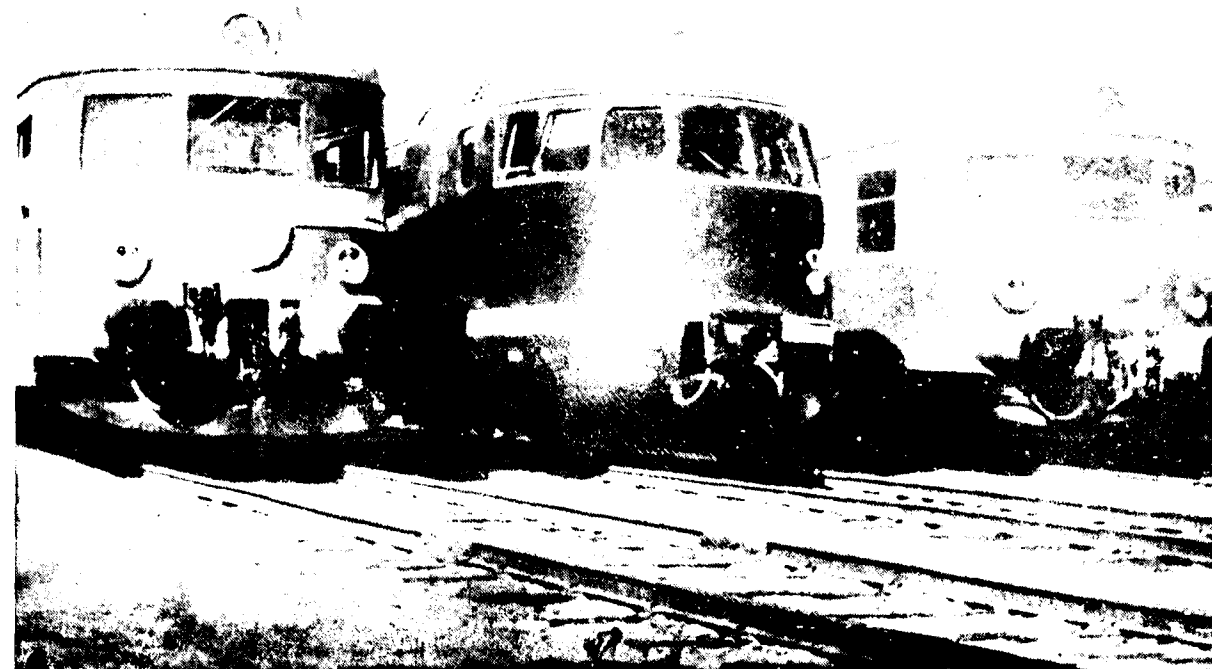


Saloon

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July 1954

THE INDIAN RAILWAY ENGINEER

MESSAGES

"Has maintained a consistently high standard" says our General Manager of Central Railway



Bombay,
21st May, 1954.



I am glad to hear that the "Indian Railway Engineer" is bringing out an Annual Number in July. I have been watching the progress of this journal since its inception and am indeed very happy to note that it has maintained a consistently high standard of publication apart from its get-up which is excellent.

I have, no doubt, that the Annual Number which is now being brought out will be an equally useful production and I wish the "Indian Railway Engineer" every success.

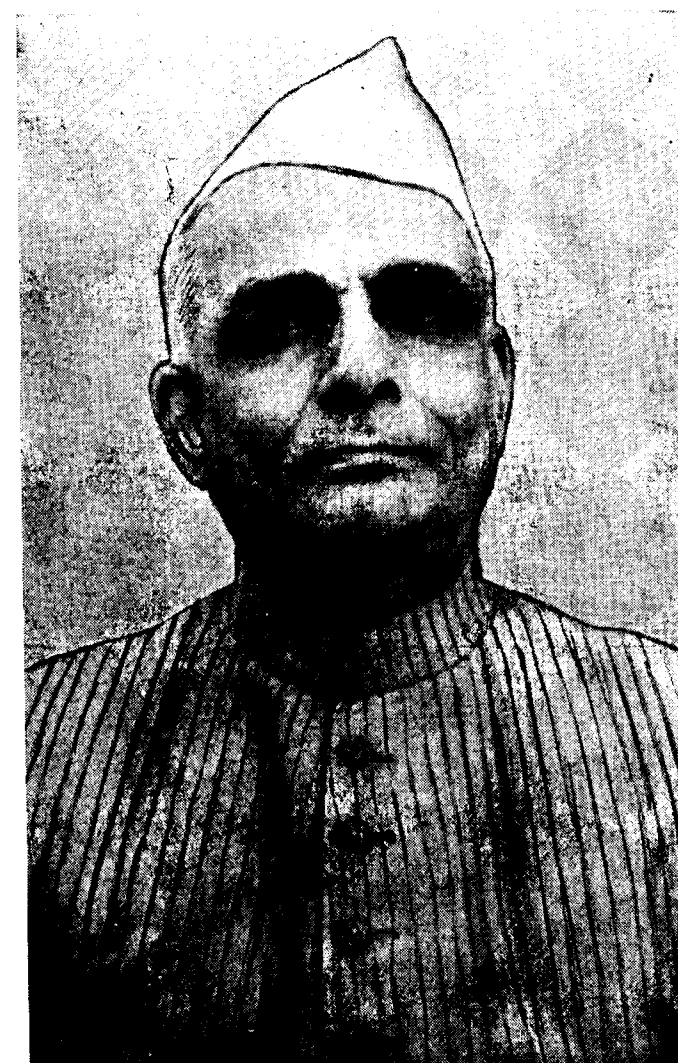
H. A. A. A.

Tributes from H. E. Governor of Bihar

Governor's Camp,
Uttar Pradesh,
May 21, 1954.

If our Railways have to be kept up-to-date, our Railway Engineers must pool their knowledge and experience and also develop new lines of improvement.

R. P. Munshi



Raj Bhavan,
Ranchi,
May 21, 1954.

It is heartening to see you bringing out your Annual Number.

The West has advanced, leaving most of the East far behind, in no other branch of knowledge so much as in applied science and technology. It is upto us now, to see that we make up for lost time.

Let there be no delusion in our minds that the age of technology is yet to come. It is already on us—with all its good and evil. We have to be abreast of the times though we should try our best to avoid as much of the evil as possible.

I am glad, this Magazine is doing its own little bit in advancing technical knowledge in a small branch.

R. P. Munshi



Nainital,
21st May, 1954.

I am glad that the "Indian Railway Engineer" has completed its first year of existence. Efficient maintenance and running of the very important carrier service of India is necessary for its growth and development. This needs efficient and up-to-date technical guidance and research. The Journal has devoted its attention to these problems and is serving a very useful need. I hope that in future years it will continue to become more and more useful not only to the country's railway system but to all others who are in need of technical guidance.

GPant



Raj Bhavan,
Simla,
26th May, 1954.

I am gratified to learn that "The Indian Railway Engineer"—the first Journal of its type in Asia—has completed the first year of its life. I feel confident that during this period the Indian Railway Engineers must have studied the contents of this Journal with interest and would have found information contained therein to be useful. I wish the Journal a ripe old age full of useful service to the country.

As Sural



Minister
Information &
Broadcasting
India,
Camp: Simla,
May 29, 1954.

I am glad to know that the "Indian Railway Engineer" has finished one year of its existence and it is progressing well. I wish it every success.

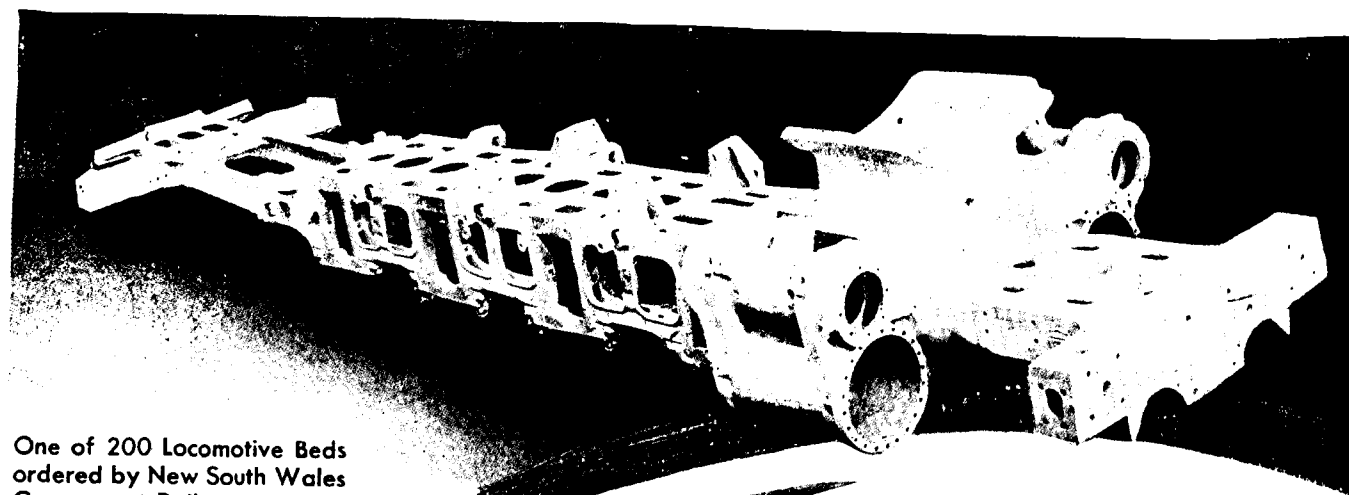
B. N. Malhotra



Srinagar,
29th May, 1954.

I am very glad to know that the "Indian Railway Engineer" has successfully completed its first year. The journal contained valuable information and matters of interest to the railways and the manufacturers of the railway equipment. The contribution which such magazines make towards development of our Industry is incalculable, and as the development of our railways is a matter of great importance to the nation, the "INDIAN RAILWAY ENGINEER" deserves patronage and encouragement.

Yuvaraj Karan Singh



One of 200 Locomotive Beds
ordered by New South Wales
Government Railways.

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Illustrated above is an exact scale model of the running gear for a steam locomotive and tender. This model was displayed at the Indian Railways Centennial Exhibition and is currently being seen throughout India on the Centenary Exhibition Train. It is equipped with the following one-piece cast steel COMMONWEALTH Products:

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Waterbottom Tenderframe
Tender Bogies

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The COMMONWEALTH Locomotive Bed incorporates in one rugged casting many parts, including main frames, cylinders, cross braces, cradle, various brackets, and many other parts. The unit bed eliminates welded, bolted or riveted connections with the accompanying maintenance problems, thereby permitting permanent alignment of moving parts and highest availability of equipment. Great strength with less weight is assured by the economical distribution of metal to sections where it is needed most for strength. Furnished completely machined, ready for application, COMMONWEALTH Beds greatly simplify locomotive construction. Hundreds of locomotive beds have been in service for many years in Australia, France, Mozambique, South Africa, Turkey, Canada, and Mexico as well as thousands in the United States.

COMMONWEALTH One-Piece Cast Steel Products have been proven in service on the railways of 55 countries. They keep locomotives in active service longer with a minimum of maintenance, permitting most efficient operation with fewer locomotive units.



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Best wishes from H. E. Governor of Orissa



Raj Bhavan,
Puri,

22nd May, 1954.

I am glad to learn that the journal "The Indian Railway Engineer" which is devoted to railway matters of technical interest, has completed one year's existence and I send my best wishes to it on that occasion. Besides affording the staff of the Railways a forum for discussing matters of professional and technical interest and for general exchange of ideas, the journal should help in interesting the public also in the many strides that are being made in the field of research in the various workshops and laboratories of our greatest nationalised undertaking.

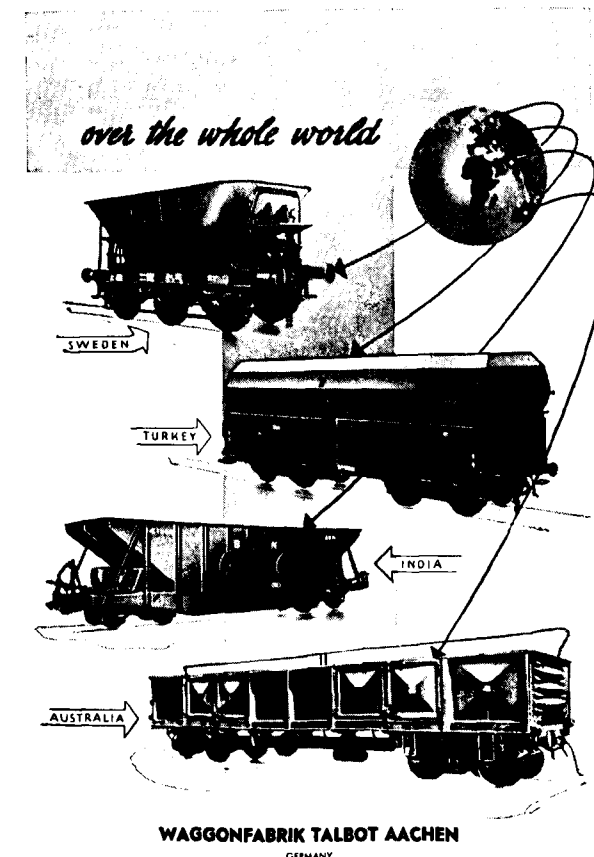
We have to achieve self-sufficiency in many matters, such as machine-tool production, as soon as feasible, and proper standards have also to be maintained in the production and servicing of all types of railway machinery. Apart from these, railway travel has also to be rendered more comfortable than it is now, and matters like travel-safety are yet to receive in our country the attention due to them. Considering the size of our sub-continent, the railway engineers, as in the case of every other class of engineers in the various other departments of national activity, have immense scope for the application of their specialised knowledge and skill, and I hope that they would do their very best to help the nation to achieve the various objectives that make for more efficient railway service.

I wish the "Indian Railway Engineer" many more years of useful service to the nation and its engineers.

ONE YEAR IN RETROSPECT

WE have completed one year's successful existence in the world of Technical Journalism specialising in "Railway Engineering". We have every reason to be proud of our achievements in various spheres in the last twelve months. The absence of an Engineering Magazine devoted exclusively to various techniques of Railway Engineering had been a handicap in recording the achievements of our Railways, the greatest nationalised enterprise in the East and the appearance of "The Indian Railway Engineer" on the scene, of course with the valuable co-operation of some Chief Engineers and other interests concerned has filled this void.

Railways have been and are playing an increasingly vital role in our economic progress in different spheres. Great strides have been made in Railway Engineering to secure increased efficiency and greater safety during the last few years. Most of these are based on technical advances made in our country as well as abroad. Apart from routine railway engineering involving development and maintenance of railway tracks and running of train services, we have gradually taken up manufacture of wagons, carriages, components, boilers, locomotives, telephones, signalling equipments and various other railway engineering equipments which were hitherto imported from abroad.



Particularly in a country like India where we have an extensive net-work of railways there is room too for improvement and further extension. Communications play a large part in the cultural and social advancement of a country. The development of railways on right lines is essential for the achievement of many of the targets laid down in the National Plans. It is therefore necessary to stimulate intelligent interest of the public in our railways and in their working. Our Journal has begun to serve some of these needs in its own humble way and we are confident that with the passage time it will become increasingly useful and thus be an effective forum for the propagation of information on this important subject.

As the Governor of Madras His Excellency Shri Sri Prakasa said in his message to our Inaugural Number in 1953 that "there has been much tampering with Railways. I wonder if it would be possible so to do things as to eradicate the possibilities of sabotage. Our Railways run through solitary forests and through forbidding mountains. They cross arid deserts and swollen rivers. The wicked have plenty of opportunity to interfere with the works and endanger precious life and property. Cannot our Engineers do something to sabotage the saboteurs and baffle their evil designs?" We can record with satisfaction during the year under review there has been marked improvement in the number of accidents and consequent loss of lives and property which could be attributed to negligence on the part of staff. The vigil and care exercised by the Officers and Men of the Railways and also the installation of some technical devices in various units have been responsible for this improvement in the situation. But there is still room for minimizing the accidents and we earnestly hope the Railway Engineers would be able to achieve this desire of the public in the near future if they continue to maintain the present rate of progress in the research sphere.

For our part we assure our co-operation to the Railways in educating public opinion in the technical problems arising out of the expansion and also working of the existing units and in assisting the administration in their solution.

We take this opportunity of thanking all those high personalities who have sent us their messages of good wishes and appreciation (published elsewhere in this issue) for their kind sentiments expressed in respect of this Journal and we can assure them that in the years to come we will further rise to their higher expectations of our achievements and in the maintenance of the present high standards of layout and get-up.

We also earnestly thank all the Chief Engineers and Higher Officers of the Railway Board for their valuable co-operation extended to this Journal whenever sought for and assure them of our willingness to co-operate with them in turn in the furtherance of national causes.

We also extend our thanks to all the Engineering firms who have been co-operating from the inception of this Journal. Our thanks are also due to our readers who have been gradually swelling our rolls for their helpful suggestions and valuable assistance in running the Journal.



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TIX 23

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 STEAM- AND DIESEL-HYDRAULIC LOCOMOTIVES

 Three detailed line drawings of locomotives are arranged diagonally. At the top right is a diesel locomotive. In the middle is a steam locomotive. At the bottom is a diesel-hydraulic locomotive. Each locomotive is shown from a side-on perspective, highlighting its unique design and components.

KRAUSS-MAFFEI
MÜNCHEN
GERMANY

HYDRAULIC RE-RAILING EQUIPMENT

Appliances operated by a pneumatic hydraulic transformer

FOR many years Maschinenfabrik Deutschland G.m.b.H., Dortmund, has specialised in the design and manufacture of locomotive and rolling stock re-railing equipment. After exhaustive trials with the firm's pneumatic-hydraulic re-railing devices known as the Deutschland type, the equipment has been standardised on the German Federal and other European railways. The Eastern Region, British Railways, has also carried out extensive trials with this equipment which now forms part of the breakdown plant of that Region.

POWER EQUIPMENT

The types of power units vary, but in all cases the lifting jacks are operated either by compressed air or hydraulic power. On the German Federal Railway the hydraulic lifting jacks are operated at a minimum pressure of 300 kg./c. m. ², the plunger pump being driven by compressed air. The pump check valves and liquid container are mounted to an aggregate and form a self-contained unit. Where the equipment is required to operate with trains equipped with vacuum brake, the pneumatic-hydraulic transformer pump is replaced by a hydraulic pump driven by a 4-5 h. p. diesel engine.

The hydraulic unit is driven by a vee-belt and friction clutch, so that the diesel engine can operate at full speed without the hydraulic unit coming into action. The pressure liquid is a thin acid-free oil, which is by-passed by means of a cut-off pump. The diesel engine set is mounted together with the pressure pump on a light frame travelling on rubber tyred wheels. Hand-operated hydraulic pumps also are available.

Various telescopic jacks are available, which are designed to give a high lift in relation to their normal height, typical capacities of which are as follow:—

Lifting capacity, tons	150/75	120/60	60/30	40/20
Normal height, in.	17.5	17.5	20	20.1
Height of lift, in.	19.4	19.4	25.8	27

The lifting jacks operate with equal efficiency when using either the pressure-liquid or pneumatic-hydraulic pump. Other types of jacks are included in the equipment which include claw jacks, of 40 tons capacity, with a lift of 30.5 in., the claw is positioned at the bottom, which enables the jack to operate at a very low point. For lifting wagons a claw jack of 16 tons capacity is available. In this design, the lift is 30.5 in., three

of this type are used in conjunction with heavy or light pin chains for raising overturned vehicles.

TIPPING JACKS

For re-railing vehicles which are derailed at one axle a special tipping jack is available with a capacity of 16 tons and of lightweight construction. A device is used to fasten the head of the jack to the buffer, and a claw on the jack provides a low lift of 2.5 in. above ground. An axle inserter serves a small jack of 10 tons capacity, which as a thrusting cylinder, is used for pushing derailed locomotives laterally after lifting.

With the exception of this jack and the special tipping jack, all are fitted with automatic non-return valves, to prevent dropping of the raised vehicle in the event of the high-pressure hose bursting. All high-pressure hose is made of Tombac, and is very flexible. It is supplied in lengths of 16.4 and 32.8 in.

LATERAL MOVEMENTS

Re-railing bridges are used for the lateral movement of locomotives. These are 6.7 and 13.1 in. long, and are composed of double rails with spacing blocks between, and a built-in hydraulic pulling cylinder. For small lateral movement a roller grid is included in the equipment which moves over a substantial steel plate with wooden base, placed between the track.

Besides what may be termed standard equipment, the firm has developed other types of plant including a hydraulic hauling device which has a tractive power of 30 tons, and used in conjunction with wire rope and pin chain.

HYDRAULIC PISTON

The stroke of the hydraulic piston corresponds to the length of the chain links, 31.5 in. At the end of the stroke an auxiliary lever is used to lock the load which is firmly held in position while the piston is returned from its advanced position.

After the removal of a chain link a further pull of 31.5 in. can be carried out, a feature which produces what is in effect an endless pull. It is claimed that this method is so closely controlled that no damage can accrue. This equipment is recommended for use for re-railing operations resulting from severe accidents. The link chain system is also used for raising overturned locomotives.

(Continued on page 7)

An account of the Ebbw Vale Section

THIS is an account of the Ebbw Vale Section of Richard Thomas & Baldwins Limited: a Section which embraces one of the biggest plants in Europe engaged in the manufacture of steel sheets and tinplate. It also includes limestone quarries at Trefil; brickworks at Brynhelig, Gantra, and Sirhowy; and a small tinplate works at Abercarn.

This is not a technical exposition, but it is intended merely as an outline of the main processes carried out at Ebbw Vale, and an introduction to the Company's largest single steelworks.

Over 7000 people are employed at Ebbw Vale Works itself, and the three-miles-long plant dominates the town surrounding it. The story that follows, therefore, is not only of a great Works: it is also the story of a famous Welsh community.

Our products are made chiefly from iron ore, limestone and coal. The coal is converted into coke, and the coke, limestone, and iron ore are then put into a blast furnace and made into liquid iron. The liquid iron is converted into liquid steel, which is then cast into ingots.

The red hot ingots are rolled first into flat slabs, then into long strips. These strips are wound into coils or cut into sheets, and then come in for treatment to remove any blemishes—'pickling', we call it. The coils are rolled again to the final specified thickness, are heat-treated to restore any quality-loss caused by rolling, get a final surface finish and tempering in the Skin Pass Mill, and after this are cut up into plates, ready for a coating of tin.

(Continued from page 6)

Auxiliary bogies have been designed for the hauling of derailed bogie vehicles. The bogie has a capacity of 20 tons, and can be loaded into the breakdown van in a dismantled condition. The bogie has a swivel bolster which enables a damaged vehicle to negotiate curves and varying heights is compensated for by a screw jack. For the unloading of equipment carried in breakdown vans a compressed air, slewing jib crane has been developed capable of lifting 5½ cwt. The crane is carried on a runway suspended from the roof of the van. The jib extends beyond the buffers at each end.

SECOND BRITISH ORDER

After successful experiments British Railways have ordered three more sets of re-railing equipment from

RAW MATERIALS

The main part of the plant lies at the top of the Ebbw Valley. The railway company's main line runs right through the Works, and delivers incoming wagons to the marshalling yards, where we take over.

The flow of raw materials into the Works; the transport system inside the Works, and the delivery of wagon loads of finished products to the railway company are the main responsibility of the Traffic Department staff—and a twenty-four hour day job it is, at that.

The main raw materials which are brought into the Works are iron ore, limestone, and coal. From the marshalling yards the coal wagons are shunted on to the 'tippler', which turns the wagons over—emptying their load through a screen on to the conveyor belt which will carry the coal to the storage bunkers.

THE COKE OVENS

The coal is automatically discharged into eight bunkers, each one holding 400 tons of coal. From these bunkers the coal, after pulverising, is then carried to the main storage bunker which has a capacity of 3000 tons. This bunker feeds the seventy-six coke ovens.

The coal is heated to some 1050°C in these ovens, and the gas that is driven off by this process goes to the by-product plant.

When the heating cycle is completed, the coal—which has now become coke—is ready to be pushed out of the ovens.

Maschinenfabrik Deutschland similar to that supplied to the Eastern Region, which includes heavy and light hydraulic jacks, self-contained mobile diesel-hydraulic pump unit, and crank and chain apparatus. The tests included re-railing of locomotives, carriages and wagons without the use of cranes.

This equipment is to be allocated to motive power depots at Gorton, Mexborough, and Darnall, where the use of breakdown cranes with jibs of normal height would present some difficulty because of the overhead wires for the Manchester—Sheffield—Wath electric services. (Reprinted from "The Railway Gazette," October 30, 1953)



M. S. ARC WELDING ELECTRODES

India's most popular electrode is now
packed in hermetically sealed tins.

**THE INDIAN OXYGEN &
ACETYLENE CO. LTD.**

IOAX/48

There are doors at the ends of each oven, and these doors are taken off by special machines. One machine incorporates a ram, which is used to push the red hot coke through the length of the oven and out into the coke car at the other end.

Coke being one of the three main ingredients used in the blast furnaces for making iron, we use anything up to 350,000 tons a year.

After quenching, the coke is graded to size and carried to the blast furnaces, which are fed with carefully measured quantities of coke, limestone, and iron ore, carried up in skips and tipped into the furnace through a special arrangement of gas-tight covers or 'bells' operated by the hoistman. He must be careful to deposit each skipload in its right position around the furnace top so as to ensure even distribution of all material.

THE IRON IS TAPPED

When the furnace is ready to be tapped, the first stage is to run off the slag—a thick scum which floats on top of the iron inside the furnace and contains a lot of the impurities originally present in the ore. We have to get rid of it before we tap the iron underneath.

The blast furnace itself is a steel tower, some 100 feet in height, and lined with firebrick. A blast of pre-heated air is blown through it under pressure from a steam turbine.

The tapping hole through which the iron comes out at the base of the furnace is plugged with clay. The hole has to be burnt through with an oxygen pipe. We usually tap off up to a 100 tons of iron at a time. We do this six times every twenty-four hours on each furnace.

MOVING LADLES

Apart from the iron at the bottom of the furnace, vast quantities of gas are collected from the top of the furnace. This is subsequently cleaned and used in other parts of the Works.

When all the iron has been tapped out of the furnace, at a given signal from the foreman a ram pushes a charge of clay into the taphole, while the ladles of molten iron are taken to the Bessemer Shop.

The first job of the Bessemer Shop is to keep the iron which comes from the blast furnaces at the right heat until it is needed for use, so the incoming ladles of metal are poured into a large drum called 'mixer', holding some 1400 tons of iron, which is heated with coke oven gas.

In Ebbw Vale we use two methods of making steel: the Bessemer Converter and the Open Hearth process.

THE BESSEMER PROCESS

We make Bessemer steel by first of pouring out twenty-five tons of iron from the mixer into a ladle containing soda ash for de-sulphurising. After any slag has been removed from the surface, an overhead crane brings up the ladle of iron to the converter. It takes about twenty minutes to convert this iron into steel.

The converter is a steel vessel, lined with refractory. Its base is a circular disc of refractory material pierced with nearly 300 holes. Air is blown through these holes at the rate of some 20,000 cubic feet a minute. This air, passing through the charge, to which lime has been added, causes certain reactions to take place.

As a result of these reactions, most of the impurities in the metal form into a slag. The air pressure, which is some twenty to thirty pounds per square inch, is such that the molten metal does not really touch the base of the furnace at all, but rests on a cushion of air all the time. The Bessemer process is very quick, and our main indication of the state of the charge inside the converter is the colour of the flame coming out of its mouth.

At a determined point during the blow, the converter is tilted down and in goes a quantity of steel scrap. When the charge is ready the converter is swung down for pouring.

Before pouring, the chargehand has a look at a sample of the steel. Like the molten iron in the Blast Furnace, there is slag on top of this steel, too, containing various impurities, so that has to be poured off first. Meanwhile the temperature of the metal is checked with a pyrometer, and the ladle for the steel is brought up.

While pouring the steel from the converter, a small ladle of molten ferro-manganese is added to deoxidise the steel.

THE OPEN HEARTH

The other steelmaking process — Open Hearth — is a slower one than Bessemer, but has advantages of its own. The furnaces are of much greater capacity than the Bessemer converters, each making around 100 tons of steel every twelve to fourteen hours.

The furnaces, which are really large gas-heated ovens, are charged with pan-loads of steel scrap, pig iron and limestone, by an electrically-driven charging machine.

These furnaces are heated by producer gas from the gas producers which form part of this plant. As with the Blast Furnaces and the Bessemer converter, the limestone, when fluxed, reacts with the impurities, forming a slag which floats on the surface of the metal.

The furnaceman forms a good idea of how his charge is progressing by his own experienced eye, and by taking out a sample, cooling it, breaking it, and judging the fracture.

ADJUSTING THE MIX

Iron ore or steel scale (oxide of iron), lime, and small additions of fluorspar are added from time to time. During this period the whole mass boils, and many of the impurities pass into the slag, while the carbon content of the steel is being continually reduced. In the meantime, samples of the metal and the slag are sent to the laboratory to be analysed.

From these laboratory tests the shift supervisor knows what modifications will have to be made to the charge in the furnace so as to obtain the quality of steel required.

When the shift supervisor is satisfied with the reports from the laboratory, he makes a final test of the heat and fluidity of the metal. If these tests are also satisfactory, he instructs the tapping crew to begin their job. They use an oxygen blow-pipe to burn through the plug in the tap hole of the furnace, and the stream of boiling metal comes pouring out into the waiting ladle.

As the metal fills the ladle, deoxidizers in the form of ferro manganese and aluminium are thrown in, to be incorporated in the final composition of the metal.

When the steel has been run out of the furnace, the ladle is lifted bodily by an overhead crane and is brought directly over a train of ingot moulds on bogies which are ready to receive the metal.

The 'teemer', as he is called, uses a lever which raises the stopper in the ladle and allows the liquid metal to run out through fireclay nozzle into each mould. The metal appears to be effervescing violently and then it begins to set around the sides of the mould. At the same time a scum of impurities forms on the surface, and this is skimmed off while the centre portion of the ingot is still in a molten state. The hot ingots are taken by a locomotive to the stripping bay, where the moulds are lifted from the ingots with the tongs of an overhead stripping crane.

At this stage the ingots, although still hot, are not hot enough for shapping, so they are placed in the soaking pits to be heated and soaked to an even temperature throughout.

The soaking pits are really big, squat, jug-shaped ovens with an inside diameter of twenty-one feet at the base. They are heated by gas (supplied from the blast furnaces and coke ovens) and oil. The ingots are brought to rolling heat, which is about 1300°C; and when the Slabbing Mill calls, the dome-shaped cover is removed from the soaking pits. An overhead charging and drawing crane then picks out an ingot and places it on an ingot bogie, which conveys it the Slabbing Mill.

SLABBING AND FLAT ROLLING

The ingots are usually about six feet long and two feet thick, the width varying according to the width of the strip required. The Slabbing Mill's job is to roll and squeeze them into slabs up to forty feet long and from four to six inches thick.

The mill itself comprises two steel housings with steel rollers revolving between the housings. As these turn in either direction, the ingot is elongated in each forward and backward pass between the rolls.

The operating controls of the shaping rolls and other mechanical devices for manipulating the ingot are all centralised in the control room—or pulpit, as we call it.

When the rolling is finished the forty-foot-long slab of metal passes under a guillotine shears and the ends are cropped to remove impurities; the rest of the slab is cut into two pieces—say, one eighteen feet long and the other one sixteen feet. This is done to make the slabs of manageable size for the next heating process.

The slabs are then conveyed to the inspection and scarfing shop, where the surface and edges of the slabs are examined and any defects in the form of loose pieces of scrap, cracks, etc., are burnt out of the surface by means of oxygen and coke-oven gas flames. This process is essential if a really good surface condition is to be obtained in the final product.

RE-HEATING SLABS

The cold slabs are lifted in bundles of four or five from the slab storage yard, and placed near a conveyor table to be fed into a pusher-type continuous reheating furnace, where the heat is built up again before more rolling can take place.

Then, at a signal from the Strip Mill, a slab is discharged from the reheating furnace on to the roller table which conveys the slab to the roughing scale breaker. This pair of rolls breaks up the scale on the surface.

From there the slab enters the squeezer, which squeezes it to the required width. It then passes through the first roughing mill, where at the same time the scale is removed by high pressure jets of water, and the slab is reduced somewhat in thickness.

After that it goes through three further roughing 'stands' or sets of rolls, each set successively rolling it thinner and thinner while at the same time increasing its length.

THE FINISHING TRAIN

Finally, the strip of steel arrives at what we call the Finishing Train. Here are six mills of the four-high type, each mill going faster than the one before, so that the strip comes out at the end at speeds up to 1800 feet a minute.

THE COILER

At the end of the line, the strip is guided into the coiler. This, as its name suggests, winds the strip into manageable coils of steel strip ready for cold processing, and it is really here that the Hot Mill process ends; for the strip rolls on to the conveyor which will carry it over the main railway line to the Cold Mill, about half a mile away.

When you remember that the Hot Mill is nearly half a mile long, you get an idea of the journey that the slab has to travel before finally coiling as strip at the far end. There are about 900 electric motors, totalling around 150,000 h. p., in this mill alone.

A certain amount of cold process work is done at the finishing end of the Hot Mill—for instance, on heavy sheets—so while the coil goes on its journey, let's go and see how they are handled.

In the case of heavy sheet steel—that is, usually, anything up to five-sixteenths of an inch thick—the strip is cut up into suitable lengths by a rotary flying shears as it leaves the Finishing Train of the Hot Mill.

The sheets go along the run-out table until they arrive at the hot sheet piler, where they are stacked into neat piles. These piles of hot sheets are then placed on the cooling bank to await further processing. The sheets are now carried to the three-sixteenths-inch Cut-up Line, then to the pickling bay, where they are tempered in the skin-pass mills and then immersed in an acid bath to

clean off the scale left on the surface after leaving the Hot Mill.

Now let us go back to those big coils of steel strip we left rolling on to the conveyor on which they travel over the main railway line to the Cold Mill.

On arrival in the Cold Mill they go through the continuous pickler first of all. This is for the purpose of cleaning off scale which is left on the surface of the metal after the Hot Mill process. We call it 'continuous' because the end of one coil is mechanically stitched to the front of the next. The pickling vat contains a solution of sulphuric acid heated by steam.

The strip is oiled and rewound into coils as it emerges from the pickler so that it will be easy to handle, and here it goes one of two ways, according to the type of product required. Some will be made into steel sheets, while others will be made into tinplate.

When the sheet coils come from the pickler they go through a rolling mill known as the 3-stand tandem Cold Reduction Mill, which reduces the thickness of the metal from around .1 of an inch to about .040 of an inch. The coils then go to the cut-up lines, where they are side-timmed and end-sheared into sheet sizes, and the stacks of sheets pass on to the annealing furnaces for heat treatment.

After annealing, the sheets go to the Skin-pass Mills, where the steel receives the final surface finish and the required temper.

Next, the sheets are inspected and go through oil-soaked rolls which give them a protective covering against rust during transit to the buyer and during subsequent storage.

Before being packed for despatch, some of the sheets are cut to close tolerances and special sizes, according to the customer's wishes.

With the Despatch Department we reach the end of the sheet production lines. Great care is taken in packing these sheets to preserve them from any kind of blemish in transit. Many of these shipments go to motor car manufacturers to be made into body panels and other high-grade products which have to have a super-gloss finish, so packing has become an art in itself.

This, however, is only *one* of the ways in which the steel can be finished off. So let's go back to the continuous pickler again and follow the tinplate process as the coils begin their journey.

THE 5-STAND MILL

First the coils go through a set of rolls known as the 5-stand tandem Cold Reduction Mill. Here the strip is rolled down from about .08 of an inch to about one-hundredth of an inch. Palm oil is run on to the strip to reduce friction during rolling, so after leaving the 5-stand tandem the coil has to go through an electrolytic cleaning process to remove any palm oil which has clung to the surface of the coil.

After being cleaned, the coils are ready for heat treatment in the annealing furnaces. The purpose of this heat treatment is to re-crystallise the steel so as to restore the softness of the metal which has been lost in the cold rolling process. The heat treatment is usually carried out at a temperature of just under 700°C. Here make use of our coke oven gas for heating.

TINNING PROCESSES

After annealing, the coils are put through the special skin-pass mill for surface finishing and tempering, and go on to the cutting lines, where they are trimmed and sheared into the required sizes. A mechanical device sees to it that anything too light or too heavy is automatically rejected.

The plates are now ready for tinning. They can be tinned in either at Melingriffith tinning machine or a Poole-Davis tinning machine, or, alternatively, coils can be continuously tinned through the modern electrolytic tinning line.

THE ELECTROLYTIC TINNING LINE

The electrolytic tinning line at Ebbw Vale was the first of its kind to be established in Europe. It embodies six units, through which the steel strip is passed continuously: from entry, through the cleaning, tinning, brightening, and oiling processes to final shearing and classification.

As each coiled strip is fed into the entry zone, it is cut square. When its turn comes, the entry zone is stopped for twenty seconds, during which the new coil's leading edge is seam-welded to the trailing edge of the coil passing through ahead of it. It is then fed into a fifty-foot-deep looping pit, where some 200 feet of coil are continuously running free in a double loop. Such surface impurities as grease and oxide are next removed.

Now the strip is ready for coating. It passes through four tanks containing an acid solution of tin sulphate

(Continued on page 13)

known as the electrolyte. Bars of tin—the anodes—are suspended alongside the moving strip, about one inch away from it, and a 45,000-amps current is passed on to the anodes, through the electrolyte, on to the strip—acting as cathode—and back again to the generators. This electrolytic current causes tin to be dissolved from the anodes and deposited on the strip in a pre-determined quantity, the whole process being under constant supervision and control.

To reclaim the substantial quantity of electrolyte carried forward in the form of drag-out, the strip is now sprayed—first with a weak electrolyte solution, then with steam condensate—and squeezed between rubber rollers.

At this stage the strip has a dull white matt appearance. To impart a bright, shining surface the deposited tin is electrically flow-melted, then immediately quenched in water to prevent oxidation, sprayed again and dried.

There remains only a final oiling process to facilitate handling, and the strip is ready for shearing to sizes as required by the customer. At three stages on its journey from the entry zone, the now finished tinplate has been inspected: twice electronically—before and after plating, for pin-holes—and once by a supervisor, who, by means of a mirror, is continuously watching both sides of the strip as it flashes past him. From any one of these points, warnings of faulty patches are at once flashed forward for automatic rejection at the shearing stage. The tinplate is finally mechanically sorted for thickness variation, and the process is complete. After the tinning processes have been completed, the sheets of tinplate emerge in all their glory. But not every sheet is up to its high RTB standard, and in the Assorting Department each is checked by inspectors; the slightest surface blemish—such as a scratch, a bent corner or a little spot—is enough for them to reject it.

The sheets are sorted, generally speaking, into five grades known as primes, wasters or seconds, waste, off-gauge and menders. The graded plates are counted off into lots of 56 sheets and taken away for boxing or piling in stillages in the Despatch Department. Once again the chemists have a say in the matter, too, from the metallurgical laboratory where tests are carried out on the sheets at various stages in the process to make sure that they will stand up to the jobs for which they are required. Customers have a habit of bringing their problems for us to solve, and this is one of the places where we try to find a solution for them.

PAXMAN RPH DIESEL ENGINES

For railway traction

THIS article deals with the RPH Series II range of Traction type Diesel Engines, which includes models in 4-, 6-, 8-, 12- and 16-cylinder vee form.

Extensive operational experience has resulted in many improvements in design. These not only give improved efficiency and performance, but also further simplify maintenance by allowing easier access to important parts of the engine.

These features include a large diameter crankshaft, chain drive to camshaft, single-cylinder heads, built-in water pumps and drives, and a double bearing is provided at the drive end of the crankshaft to permit direct coupling.

This latest version of the RPH engine—the RPH Series II—is dealt with in detail in the specification on the following pages.

The advantages of the RPH II engines lie in their compactness and low weight in relation to their wide power range, resulting in power units which are adaptable to all classes of locomotive in this power range, particularly where severe axle load limitations are in force. The multi-cylinder design provides a smooth torque, and the small stroke (7½ in.) results in a moderate piston speed. All working parts are readily handled without mechanical aid, and particular attention has been paid to accessibility.

Full details of dimensions, weights, ratings, and a descriptive section are to be found in this article. It should be noted, however, that the particulars given in this article are not binding, and are provided for guidance only.

The traction rating represents the power which the engine will develop for normal railway operation. This

ENGINE RATINGS

MAXIMUM TRACTION RATINGS OF THE RPH SERIES II ENGINE

	Speed rpm	4 RPH		4 RPHX		6 RPH		6 RPHX			
		bhp	bmp	bhp	bmp	bhp	bmp	bhp	bmp		
TRACTION	1,000	133	88.5	167	110.5	200	88.5	250	110.5		
	1,250	167	88.5	208	110.5	250	88.5	313	110.5		
RATING		8 RPH		8 RPHX		12 RPH		12 RPHX		16 RPHX	
		bhp	bmp	bhp	bmp	bhp	bmp	bhp	bmp	bhp	bmp
	1,000	267	88.5	333	110.5	400	88.5	500	110.5	667	110.5
	1,250	333	88.5	416	110.5	500	88.5	625	110.5	833	110.5

(bmp in lb./sq. in.)

Speeds up to 1,400 rpm may, under certain circumstances, be permissible on reference to the Makers.

The suffix 'X' denotes that the engine is pressure charged

(Continued from page 13)

This is the end of the mechanical processes. Though there is much more to be done, it is mainly routine stuff-packing, trade-marking and stencilling the consignments with the customer's address.

And what of the people behind all these jobs? We are a highly mechanised plant, yet it is the man who runs the machine or furnace who counts and is responsible for

making the product what it is—and on the whole, we are pretty proud of the job we turn out.

Wherever we send them, to whatever corner of the world, these packages carry our trade-mark and our good wishes. And with them go the team-work, the experience of blast furnaceman, steel man, mill foreman, packing man typist, electrician, book-keeper or stores clerk—they have all given something vital to the product.

rating is equivalent to the British Standard 12-hour rating as laid down in BSS 649 : 1935 including Amendment No. 1 : May 1936

Normal conditions of temperature and altitude are regarded as follows :

- (a) Ambient temperature up to 85°F (29°C).
Altitude : Up to 500 feet (150 metres) above sea level.
- (b) Ambient temperature up to 78°F (25°C) at sea level.

ALLOWANCES FOR TEMPERATURE AND ALTITUDE

- (a) 1 per cent reduction output for each 5°F (2.8°C) rise above 85°F (29°C) and reduction of 4 per cent per 1,000 feet (300 metres) for altitude over 500 feet (150 metres).
- (b) The determination of derating allowance in the case of turbo-charged engines will be made by the Makers upon receipt of full information regarding site conditions.

FUEL CONSUMPTION—lb/bhp/hr.

		RPHL	RPHXL
Full load	1,250 rpm	0.42	0.42
	1,000 rpm	0.40	0.40

SCHEDULE OF WEIGHTS

Mark	Net		Water in Jackets		Oil in Sump		Gross	
	lb	kg	lb	kg	lb	kg	lb	kg
4 RPH	4,800	2,177	80	36	150	68	5,030	2,281
4 RPHX	5,050	2,291	80	36	150	68	5,280	2,395
6 RPH	5,975	2,710	120	54	225	102	6,320	2,866
6 RPHX	6,333	2,873	120	54	225	102	6,678	3,029
8 RPH	6,800	3,084	160	73	300	136	7,260	3,293
8 RPHX	7,190	3,261	160	73	300	136	7,650	3,470
12 RPH	9,875	4,479	240	109	360	163	10,475	4,751
12 RPHX	10,775	4,888	240	109	360	163	11,375	5,160
16 RPHX	12,950	5,874	320	145	585	265	13,855	6,284

Net dry weights include, for normally aspirated engines : Dry exhaust manifold, air intake filters, lubricating oil filters, lubricating oil strainer, integral oil piping, water pumps, integral water pipes and manifolds, viscous damper and flywheel where required, duplex fuel oil filter and integral fuel piping.

For Pressure-charged Engines : As above, including turbo chargers, but excluding intake air filters, which are integral with the turbo chargers.

		RPHL	RPHXL
$\frac{3}{4}$ load	1,250 rpm	0.41	0.41
	1,000 rpm	0.40	0.40
$\frac{1}{2}$ load	1,250 rpm	0.44	0.44
	1,000 rpm	0.43	0.43

Above consumptions are based on fuel to BSS 209 : 1947 Class A.

Net calorific value : 18,300 BThU/lb (10,714 cal/Kg)

Viscosity : 45 secs (Redwood No. 1)

Sp. gr. : not exceeding 0.88

Fuel consumption figures are guaranteed with a tolerance of 5 per cent.

The Makers should first be consulted if fuel to any other specification is to be used.

LUBRICATING OIL CONSUMPTION

The consumption will vary between 0.5 and 0.75 per cent of the fuel consumption, depending upon the duty.

COOLING

Water and oil circulation rates and heat dissipation rates vary in accordance with engine outputs and applications, and therefore reference should be made to the engine makers for these particulars in order that the correct cooling equipment can be designed.

ANCILLARY EQUIPMENT

Individual applications may require provision of additional items, the weight of which is not included in the above table. Such items as fly-wheels, lubricating oil priming pumps and motors, couplings, 24-volt electric starting equipment and fabricated steel underbed require separate consideration depending upon the nature of the duty, type of transmission etc. We shall be pleased to submit full particulars upon receipt of enquiry.

"P&M" RAIL & FLANGE LUBRICATORS



Statistics show that use of "P. & M." Lubricators has saved Railway Administrations large sums of money on rail turning and replacement in curved track and on reduction in wear of Switch Blades.

The "P. & M." RAIL & FLANGE LUBRICATOR provides by positive action a long distance carry of GRAPHITE GREASE to curved track, to Switch Blades, and to marshalling yard lay-outs and Ladders.

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DIMENSIONS

Engine									
MARK	E	F	A	B	C	D	G		
4 RPH	48		44½		40		19¼		
4 RPHX		56½		42½		39	19¼		
6 RPH	57½		44½		40		19¼		
6 RPHX		65½		42½		40	19¼		
8 RPH	69½		44½		40		19¼		
8 RPHX		81½		42½		47	19¼		
		A	B	C	D	E	F	G	H
12 RPH			50	32	47	92		62½	
12 RPHX		58½		32	47	92	102½	62½	59¼
16 RPHX		59½		32	47	115	125½	62½	62

All above dimensions in inches.

PAXMAN RPH ENGINES

The engines are designed for direct coupling to traction generators where electrical transmission is employed, the complete power unit being mounted on a fabricated steel underbed.

For mechanical transmission, the engine and gearboxes are mounted independently to the locomotive frames with a suitable coupling for power transmission.

Features of the design include a one-piece cast crankcase which carries an underslung crankshaft in bearings amply proportioned and located in the crankcase by deep-fitting faces.

Hardened and tempered liners are specified to ensure maximum life of liners, rings and pistons.

Pressure-charged models are fitted with exhaust gas turbo-chargers, enabling the output to be increased without raising mechanical stresses.

CRANKCASE

This comprises a single casting of great rigidity carrying the underslung crankshaft in main-bearing housings of ample proportions. In addition to the usual main-bearing cap retaining studs, the caps on the 12- and 16-cylinder engines are further secured by horizontal transverse bolts. These through bolts assist in providing rigidity to the longer 12- and 16-cylinder crankcases. Provision is made in the crankcase for removal of pistons and connecting rods downwards.

CONNECTING RODS AND LARGE END BEARINGS

The connecting rods are heat-treated carbon steel forgings of 'H' section and are accurately matched for weight and balance. They are of fork and blade construction and are fitted with thin wall, prefinished, steel backed, copper-lead lined, lead flashed bearing shells. The fork rod is attached by four fitted bolts to a high-precision machined large end block. The large end block carries the crankpin bearing and provides a chromium plated outer track for the oscillating blade rod bearing.

CRANKSHAFT AND MAIN BEARINGS

The heat-treated alloy-steel crankshaft is carried in steel backed, copper-lead lined, lead-flashed bearing shells, and has a rigid flange at the driving end for power transmission purposes. In the case of the 4-, 6- and 8-cylinder engines there is a smaller flange at the free end for auxiliary power take-off purposes.

Wide bearings ensure a moderate bearing pressure, and at the drive end, double bearings are arranged to provide adequate support for the larger superimposed weight of any driven unit.

CYLINDER BLOCKS AND LINERS

Cast-iron cylinder blocks carrying the prefinished dry-type cylinder liners are attached to the upper face of the crankcase. These cylinder blocks provide adequate water jacketing, and suitable cleaning facilities are provided. The cylinder blocks are cast in 2, 3- and 4-cylinder units and allow the maximum degree of standardization.

CYLINDER HEADS

The 4-, 6- and 8-cylinder engines are fitted with cylinder heads covering two and three cylinders each. 12- and 16-cylinder engines have single cylinder heads. The combustion chambers in all cases are of the Ricardo Comet, Mark III design.

INJECTION EQUIPMENT

The fuel pumps are of the monobloc type, each with four, six or eight elements, and totally-enclosed camshafts. They are gear-driven from the engine camshaft.

All engines are provided with fuel feed pumps to ensure a positive supply of fuel under pressure to the injection pump gallery. A service tank to provide gravity feed, and its associated independently-driven transfer pump, may be omitted if provision is made for

a capacity vessel to be mounted on the engine, and charged by the feed pump.

The injectors are the single-hole pintle type spring loaded; they are readily accessible and may be removed without disturbing cooling water joints.

GOVERNOR

4-, 6- and 8-cylinder engines have integral fuel pump mounted governor. 12- and 16-cylinder engines, a fly-weight hydraulic servo governor driven by bevel gearing from the engine camshaft, the main lubricating oil pressure acting as a medium to operate the fuel pump control. By this means a small and compact governor of great sensitivity has been evolved which gives full control throughout a wide speed range. A feature of particular value is the exceptionally light adjustment required which facilitates the setting of remote control. The governor is so arranged that, in the event of the failure of the lubricating oil pressure, the engine is shut down automatically.

LUBRICATION

Forced lubrication is employed throughout, by means of engine-driven pumps. The main pressure pump is of the gear type, driven from the crankshaft and having a large-bore, short, suction pipe. Oil is distributed to the bearings via a control valve, a large capacity filter and a distribution valve. The filter and valves are located externally to facilitate servicing. Supply to the valve gear and camshaft is at a reduced feed.

The sump is of sufficient capacity to ensure long periods of operation without the addition of extra lubricant. It is fitted with a large-size drain for rapid emptying, and a dip stick for oil level indication. A second oil pump, of the same general design as the main pressure pump, is employed for the cooling circuit, which is therefore completely independent of the main pressure system.

CAMSHAFT AND VALVE OPERATING GEAR

4-, 6- and 8-cylinder engines : A one-piece camshaft of case-hardened steel, ground on all working surfaces, is housed within the crankcase between the cylinder banks. The cams operate the push rods via roller type followers

carried in the cylinder banks. The camshaft is gear driven from the free end of the engine.

12- and 16-cylinder engines : The camshaft, of case-hardened steel is in halves, ground on all working surfaces, and carried in a detachable cambox secured to the top of the crankcase in the vee formed between the cylinder blocks. The cams run in an oil bath, and operate swinging tappet levers (with roller followers). The tappet lever and roller bearings are pressure lubricated. The camshaft is chain driven from the drive end of the engine.

PISTONS

The pistons are in aluminium 'Y' alloy and are heat treated. Rings are of high-grade cast iron and are five in number, three pressure and two oil control. One oil-control ring is housed above the gudgeon pin and the other below.

Gudgeon pins are in a high percentage nickel, case-hardened steel, hollow bored and retained by circlips. Small-end bushes are of silicon bronze.

PRESSURE CHARGERS

Twin exhaust gas turbo-chargers are fitted in the case of the 12- and 16-cylinder engines, and a single exhaust gas turbo-charger for the 4-, 6- and 8-cylinder engines. Operating on the well-known Buchi principle, the pressure chargers are standard and fully tested machines. Exhaust piping connects with two turbine inlet ports of each charger, the outlets being ducted straight up through the roof of the locomotive. The air inlets are fed through viscous-type filters mounted direct on the turbo-chargers, or through remote filters and ducting, if desired.

Air delivery from the compressor volutes is by trunking to the engine inlet manifolds.

STARTING

The engine may be started either by separate electric starter motor, compressed air, or motoring by the main generator in the case of diesel-electric sets. Suitable automatic starting arrangements can be made to meet individual requirements. Automatic lubricating oil priming can be provided by means of a motor-driven pump, the control of which is interconnected with the engine starting system.

GROUPE FRANÇAIS

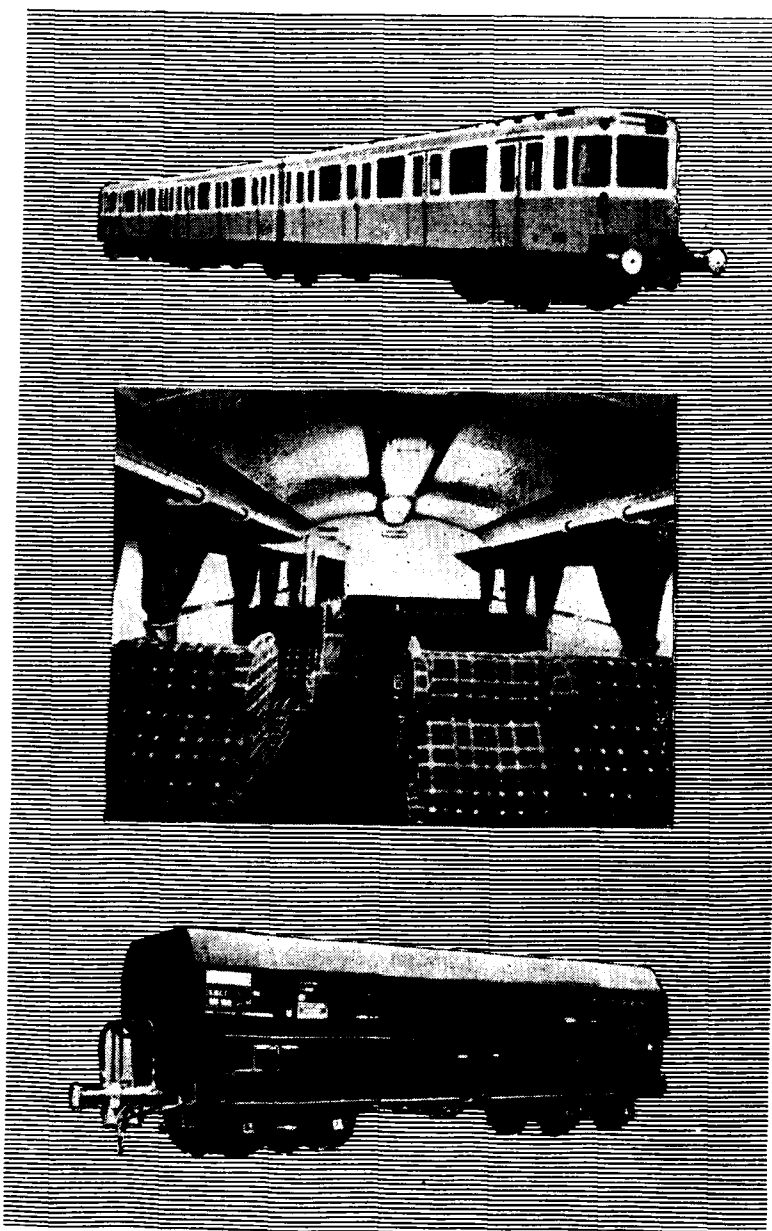
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July 1954

THE INDIAN RAILWAY ENGINEER

19

CIRCULATING WATER SYSTEM

Centrifugal pumps, mounted at the free-end and gear driven from the crankshaft, are provided on all models. The design embodies a cast-iron casing which houses a bronze impeller and stainless-steel shaft. The shaft is supported in plain bush bearings pressure lubricated by engine oil.

Inlet manifolds are secured to the lower portion of the cylinder blocks by flanged joints, flexible hose connection being provided in the pump delivery piping. Outlet manifolds are connected to the cylinder heads by short pipes and are located above the vee between the cylinder banks.

Thermostatically controlled bye-pass valves are recommended for temperature control and are available in a range of standard sizes, each embodying two, three or four of the same bellows-operated valve unit, the number depending on the total water flow.

In applying a Paxman engine to rail traction duty, various aspects of the installation call for close consideration, and the following notes, based upon experience in all classes of service, are offered for guidance.

MAIN DRIVE

Careful consideration is given to every application in order to ensure that the torsional vibration characteristics of the engine in conjunction with the driven unit shall be satisfactory. A flywheel is fitted where required and controlled flexibility is secured by choice of well-trying couplings.

Engines may be direct coupled to single-bearing generators, and a viscous-type damper is, if required, mounted on the free end of the crankshaft.

ENGINE CONTROL

Where multiple-unit operation is required, engine speed control may be effected by electro-pneumatic means and we have developed a simple and robust unit for this purpose. Alternatively, where single locomotive driving only is needed, the governor speeder lever may be actuated by mechanical means from the driver's controller. With electric transmission, an accurate reliable torque regulation system is available for incorporation in the standard hydraulic governor.

Protection against failure of the lubrication or water circulation systems may be provided by means of a range of standardised switch units, each of which is wired in circuit with an 'engine run' valve. This valve, which is of the electro-hydraulic type, is located in the lubricating oil supply pipe to the governor and remains energised to permit the engine to run, shutting down the engine when de-energised.

Engine 'stopping' may also be arranged by direct mechanical actuation on the fuel bar, and a centrifugally-operated trip for emergency shut down on overspeed is also available.

A wide range of instruments built to traction standards of robust design is offered either for remote mounting in the driving compartment or for housing in a resiliently-mounted panel on the engine.

ENGINE MOUNTING

Where mechanical transmission is used, the engine may conveniently be bolted direct to bearers which form an integral part of the locomotive main-frames. This is the usual type of layout adopted for shunting and industrial locomotives of the plate-frame type.

For lighter classes of vehicle, such as railcars, we can supply independent mounting of engine and transmission gear by three-point suspended sub-frame, with due allowance for relative movement provided by cardan shaft drive.

Diesel-electric traction power units incorporate a lightweight, yet robust, fabricated steel underbed, which forms the foundation member for engine and generator group. Although a standard pattern is employed, alterations may readily be made to suit the underbed to accommodate any particular foot-mounted generator.

It is, of course, important that the underbed should not be subjected to stresses on account of frame distortion, and that the machinery should be protected as far as possible from rail shocks. For this purpose, the Paxman steel underbed may be adapted to the conventional three-point trunnion and pedestal mounting system or arranged for support on uniformly spaced resilient pads.

Beyer-Garratt Locomotives for New South Wales

An outstanding design of a high tractive effort on 16-ton axleload, capable of running over practically the whole system

THE railways in New South Wales have been operated by the New South Wales Government since their inception in 1855. They now comprise the largest industrial undertaking in the Commonwealth, serving a population of 3,000,000. The railway, of standard gauge, includes over 6,000 route miles of line entailing long and heavy hauls, and approximately 8,390 miles of single track, including sidings, the rail reaching Brisbane (613 miles) in Queensland, Broken Hill (699 miles) near the South Australian frontier and Albury (402 miles) on the Victorian frontier.

On June 30, 1951, 1,159 locomotives with a tractive effort of 33½ million lbs., 2,891 passenger vehicles and 26,056 goods wagons were in service. The unprecedented demand during the War years, 1943 and 1944, brought the goods traffic to a total—the highest ever—of 19½ million tons, and it was only by a magnificent effort on the part of the railway that the situation was met.

At this time, however, many locomotives had reached their date for scrapping, so that the total tractive effort available in recent years has been insufficient to meet the expansion in goods transportation by rail commensurate with the growth of industry. Thus, with the abnormal use of locomotives during the War years (when it was impossible to carry out adequate repairs, neither could new locomotive power be obtained with quick delivery), the New South Wales Railways have had to examine every avenue to augment their motive power and various orders have been placed both in Australia and overseas.

One of the most outstanding orders placed has been one from Great Britain for 50 Beyer-Garratt articulated locomotives of considerable size and power, from Beyer, Peacock & Co., Ltd. These locomotives, of which this article is the subject, rank among the largest and most powerful locomotives built in Europe, and are not only

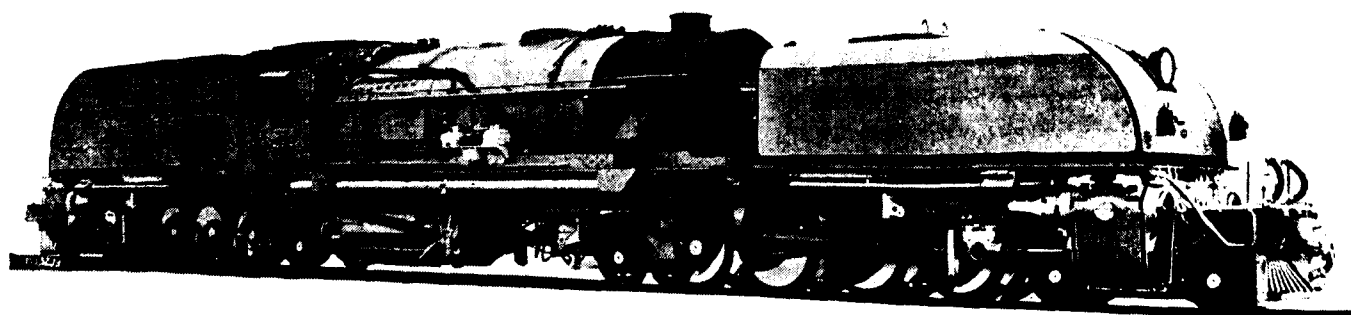
conspicuous as regards their size, but provide an example of the most modern developments in design, both in general and detail. It may be mentioned that between 1866 and 1914 Beyer Peacock supplied nearly 400 locomotives to these railways, of which a number are still in service.

GENERAL DESIGN

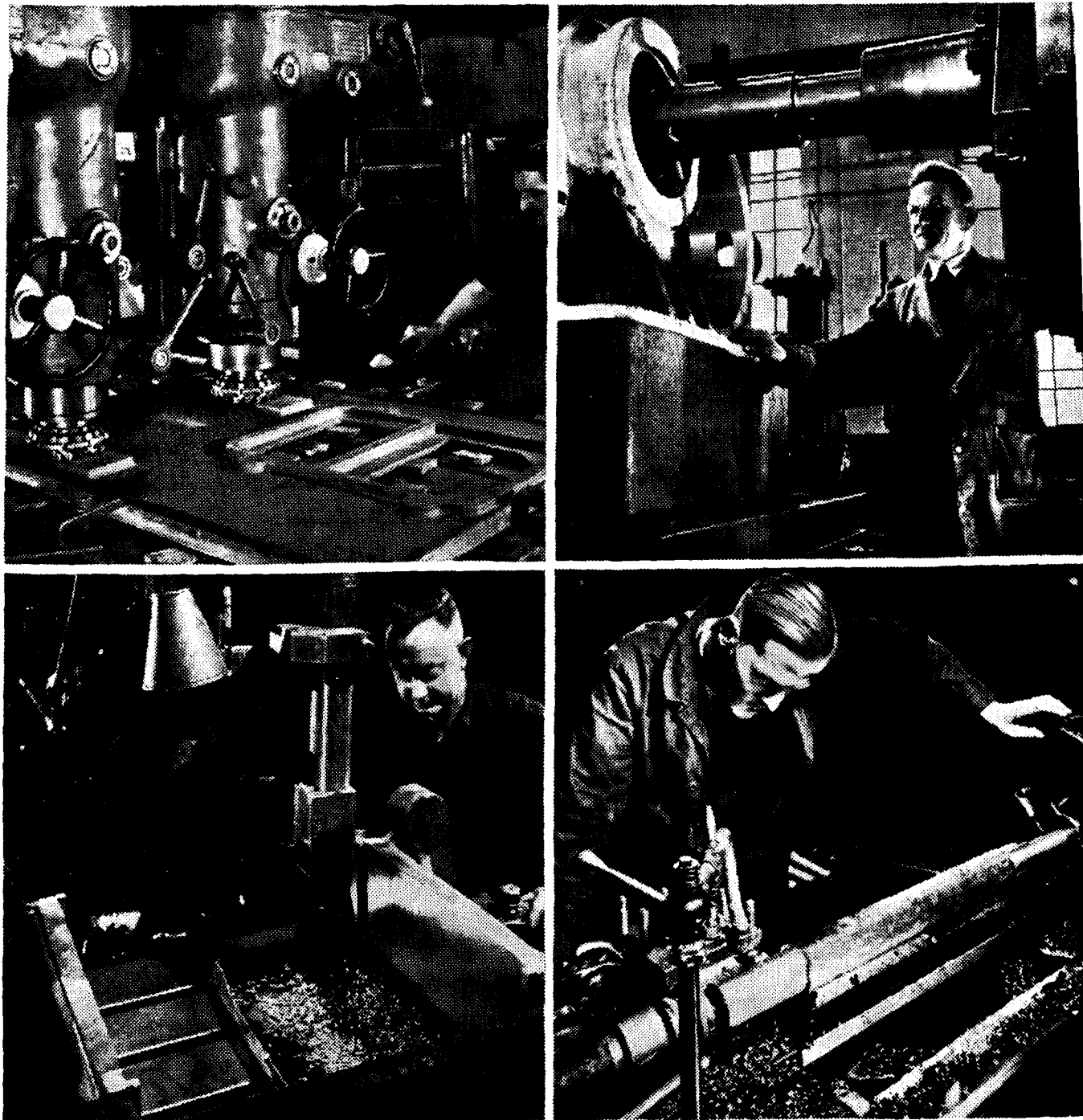
The New South Wales Railways have long been known by the outstanding designs of the class "C38" high speed passenger and the "D57" and "D58" eight-coupled goods locomotives. The Beyer-Garratt locomotives embody the latest practice of the pioneers, designers and builders of this type of articulated locomotive. They also incorporate wherever possible, the most modern practice of the New South Wales Government Railways, and embody every possible arrangement in design and lubrication to minimise running shed maintenance between general repairs.

Cast-steel beds, manufactured by General Steel Castings Corporation, were incorporated in the class "D57" as far back as 1929, and more recently in that of the Class "C38" and class "D58." It was specified that these should be included, if possible, in the new engine unit frames. Thus it is that these are the first Beyer-Garratt locomotives to be fitted with the cast-steel bed cast by General Steel Castings Corporation in their works at Granite City, U. S. A.

The cast-steel beds in these locomotives embrace the cylinders as well as the normal stays and brackets. The boiler, as will be noted, is of considerable dimensions, and fed by the Standard mechanical stoker. Both bogie and coupled wheels are fitted with roller bearings. The valve gears are operated by the latest type of Hadfield precision control steam reversing gear.



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July 1954

THE INDIAN RAILWAY ENGINEER

21

The first batch of 25 Beyer-Garratt locomotives for these railways are now well under way and several have been shipped. Designed to a coupled axleload of 16 tons and to negotiate in yards a 6 chain curve with $\frac{3}{8}$ -in. widening, and 108 ft. 7 in. long over buffers, weighing 255 tons, these locomotives will be capable of running over most of the lines of this great railway system. The loading gauge permits a 14 ft. height and 9 ft. 8 in. width.

PROPOSED ELECTRIFICATION

While there is a great amount of 60 lb. rail and 80 lb. and heavier rails more or less due for renewal on which these engines will be able to run, they will, according to information, be first introduced on the two main lines, Sydney to Wallarawang due West of Sydney, and to Newcastle in the North, and later to Goulburn in the South, the mileages being 106, 104 and 137 respectively from Sydney. These lines are in due course to be electrified in the order named and a commencement is being made with the Western section for which the equipment has been ordered. The heavy goods traffic on these lines is mainly handled by the "D57" and "D58" Mountain type locomotives of 56,000 lb. tractive effort with axleloads 22½ tons assisted where necessary with 2-8-0 type locomotives.

The engine power available is now insufficient to meet the heavy traffic offering on these sections, and consequently more steam locomotives are required. As electrification develops, the need for steam locomotives with 22½ tons axleload will be less, and the need for equally powerful locomotives with axleloads of 16 tons greater, because the latter can be used on practically all the other lines. Thus it has been considered that the

Beyer-Garratt locomotive is the answer to this problem inasmuch as it has been designed to develop a tractive effort equal to or even greater than their class "D58."

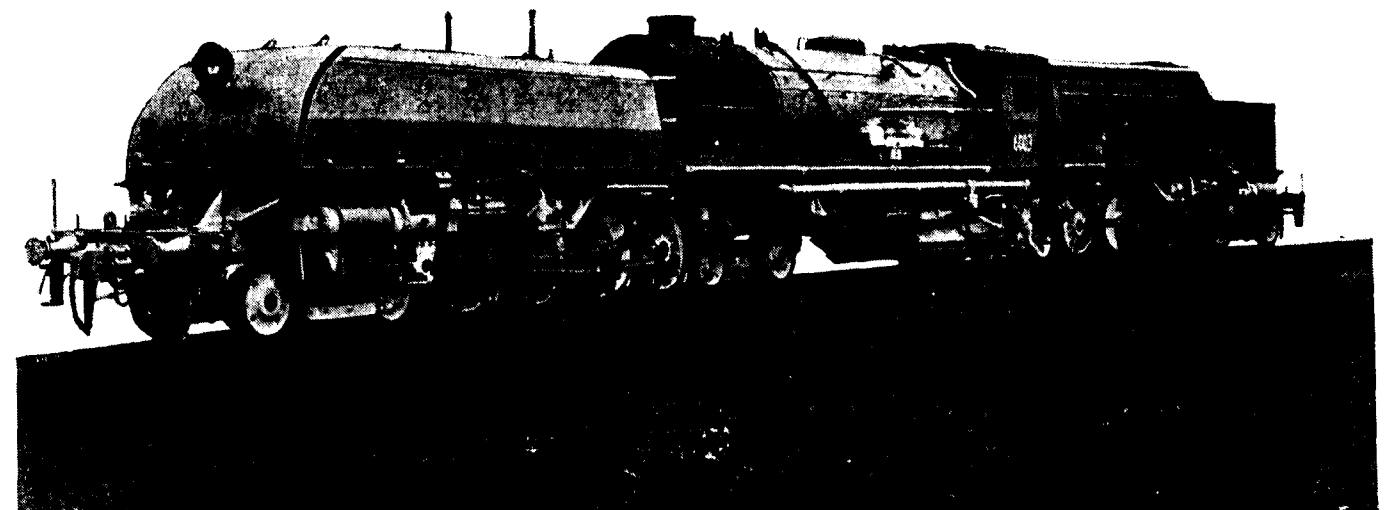
This contract has been under the general supervision of the office of the Agent-General for New South Wales (Hon. J. M. Tully, M. L. A.). The locomotives have been designed to the specification and special requirements of the previous Chief Mechanical Engineer, Mr. Harold Young, and of Mr. W. H. Armstrong, the present Chief Mechanical Engineer.

BOILER DESIGN

The size of the boiler may be judged from its dimensions, as the fullest possible advantage has been taken of the Garratt articulated design which enables a firebox of the maximum dimensions to be incorporated with a large diameter barrel. The firebox is of the round top type and the outer wrapper plate is 24 ft. in length before rolling to shape. The inner firebox is of steel of Colville's firebox quality and is of riveted construction throughout.

All the tubes, of solid-drawn steel to B.S.S. No. 494, are fitted with copper ferrules at the firebox tubeplate end, all being rolled, prossered and beaded over at this point. The flue tubes are rolled and beaded over at the smokebox tubeplate and the small tubes rolled over with the exception of 60 which are rolled and beaded.

The foundation ring is of mild steel, fabricated by electric arc welding, and machined on the surfaces in contact with the firebox plates. Water space stays are of Longstrand steel with flexible stays arranged in the breaking zone. Flexible roof stays are fitted at the front



4-8-4 plus 4-8-4 locomotive supplied by Messrs. Beyer, Peacock & Co. Ltd., to the New South Wales Government Railways, Australia.

of the firebox, the simple shape of the box lending itself to efficient staying arrangements with the minimum of obstruction to waterways.

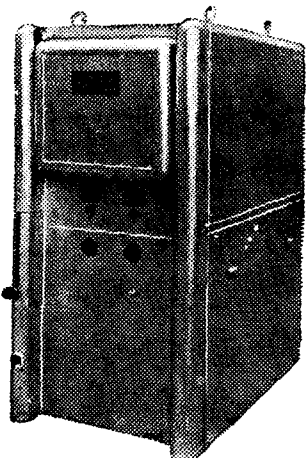
The first 25 of these locomotives have five steel arch tubes 3 in. diameter in the firebox, but the second 25 will have two thermic syphons. The size and arrangement of the superheater is worthy of notice, the 50 elements providing 750 sq. ft. of superheating surface. It is of the latest design from solid-drawn steel tubes with integrally forged return bends and ball joints. The regulator is of the multiple-valve type incorporating recent detail improvements with the valves on the saturated side.

A Melesco steam dryer is fitted in the dome. A separate drifting valve has been incorporated in the header in accordance with New South Wales practice. All this equipment is supplied by the Superheater Co. Ltd. An adequate and accessible arrangement has been made of washout plugs and doors, all of which, including the fusible plugs, are of the New South Wales standard. Two Everlasting type blow-down valves are arranged on the throat plate and the boiler is provided with a continuous blow-down valve of the railway's

standard pattern. This is located on the firebox back as is also a water sampling valve.

The boiler is fed by two Davies & Metcalfe type 1918B live steam injectors operated by quick-acting injector steam valves on the firebox side. Water is delivered through the railway's standard pattern clack boxes positioned on the top of the front course of the boiler. The main steam turret is mounted on top of the firebox outside the cab front plate and all valves are conveniently arranged for remote control in the cab. All the work on the boiler and the tests carried out at the maker's works are in accordance with the requirements of the Australian Boiler Code, but all materials conform to British Standard Specification.

The smokebox is of straightforward design and arrangement and is self-cleaning. A cast-iron blast pipe is fitted with blower ring and the whole smokebox is very strongly constructed. The wrapper plate is in one piece, the smokebox tubeplate being of the drumhead type and the whole is supported on the boiler frame by cast-steel supports on each side. The main steam pipes are solid-drawn steel with cast-steel pipe elbows.



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The chimney, smokebox door, and other details, are in accordance with the railway's standards.

FIREGRATE AND MECHANICAL STOKER

The firegrate is arranged for hand rocking in four sections by single control lever and the bars are the Waugh-Gould type, special gear being provided in the cab for alternative interlocking so that individual sections of the grate can be rocked or rocking can be to a wide angle for dropping the fire. It is designed for coal having an ash content up to 20 per cent. and a calorific value varying from 10,500-12,000 B. TH. U. s.

The fullest possible use is made of the unobstructed space available to have an ashpan of maximum proportions of the self-cleaning hopper type with side air doors operated by levers from the cab. The bottom emptying doors which discharge between the rails are hand operated. An Everlasting blow-off cock is arranged under the platform, serving as an ashpan drench.

With a grate area of 63.4 sq. ft. and the need to burn efficiently coal of varying and inferior quality, it is natural that a mechanical stoker should be a necessary feature. The long-proved standard "HT" type stoker with 5 in. x 5 in. engine has been very conveniently arranged. All controls are conveniently arranged on the fireman's side with, in addition to the engine throttle valve, an engine booster valve which gives quick action for emergency use.

The five jet valves ensure careful control of the firing from the table plate and the reversing valve under the platform is easily operated for quick reverse of the conveyor screw when this is necessary. A Nathan type "S" mechanical lubricator provides the lubrication for the stoker engine cylinders the crankshaft and associated parts being lubricated on the splash system from the engine sumps.

ENGINE AND BOILER UNITS

The frame of each engine unit is composed of one integrally cast steel locomotive bed incorporating the cylinders and valve chests, manufactured by General Steel Castings Corporation of U. S. A. To meet the special requirements of the railway, the buffer beams are a separate steel casting. Each cast steel frame bed weighs approximately 13 tons.

The boiler unit frames are of steel plate to B. S. S. 24, Part 6, No. 17, and particular attention has been given to the frame stretchers and stays to ensure the utmost rigidity and strength. The pivot centres are incorpo-

rated in a cast-steel frame stretcher at each end of the boiler unit. They are of the latest Beyer Peacock patent self-adjusting type with spring-loaded side bearers, and are mechanically lubricated from the main mechanical lubricators on the units, plus auxiliary syphon feeds to the top face.

The cylinders are fitted with renewable cast-iron liners, inside diameter 19½ in., but provision has been made for boring out of these liners to 20½ in. diameter at some future date. The pistons have steel centres with renewable cast-iron bull rings riveted on, and the cylinder covers have breaking grooves in accordance with the railway company's practice. The 10 in. diameter piston valves are trick ported with three rings on each head, the trunk way between making steam connection between the trick ports which occur between the first and second rings on the heads.

A special design of tail rod support for the valve spindle makes use of a small crosshead working on a guide and it is totally enclosed by a bolted cover. Automatic water-pressure release valves of the railway's standard type are fitted on the sides of the tanks and piped to isolated valves on cylinder covers. The cylinder and steam chest drain valves are operated with compressed air by means of a small cylinder located on each main cylinder.

Both the main piston rods and the valve spindles are provided with King type metallic packing supplied by the United States Metallic Packing Co. Ltd. A straightforward arrangement of Walschaert's valve gear has been possible and the die blocks are in the lower or direct half of the link on both units when running chimney first. A valve travel of 6½ in. is obtained in full gear. The latest design of Hadfield power reverse gear makes for the easiest possible operation by the driver, the operating cylinders being conveniently arranged on the side of the boiler unit frame. Straight line operation has been achieved with the main reversing rod. Positive and accurate selection of cut-off with a complete absence of creep is ensured with this gear.

The Laird type crossheads are of cast steel and are fitted with cast-steel sleepers lined with white metal. The slide bars, spindle guides, reversing link trunnions and reversing shafts are mechanically lubricated but the rest of the motion has the Ajax system of soft grease lubrication. The connecting and coupling rods are of forged steel to B. S. S. 24, Part 4, No. 8, Class C, and an interesting feature is the provision of roller bearings on the driving crank pin.

The intermediate crankpin has a renewable bronze floating bush in the eye of the coupling rod working in a hardened-steel fixed bush, which enables replacement of the floating bush to be made without dropping the rods and the consequent disturbance of the roller-bearing assembly on the driving pin. The small end of the connecting rod is fitted with a pressed-in bronze bush whilst the large end of the connecting rod and the driving crankpin bearing of the coupling rod are fitted with Skefko self-aligning roller bearings mounted on tapered sleeves and designed for grease lubrication. The other coupling rod bushes fitted with lead bronze fixed bushes are also grease lubricated.

The coupled horn channel liners and the wedges for the coupled axleboxes are of phosphor bronze with steel wedge adjusting bolts, and all coupled axleboxes are of cast steel and are fitted with double row Skefko self-aligning roller bearings which are grease lubricated. The horn guides are mechanically lubricated by oil. The axleboxes have manganese-steel renewable liners on the horn guide wearing surfaces. The bearings are of particular interest and a feature has been the arrangement and mounting on tapered sleeves, thus making it possible to withdraw the bearing and move it towards the centre of the axle exposing the axle journals for examination.

All axleboxes are designed to suit overhung springs of the laminated type and compensation is arranged throughout the coupled wheels on each side of the engine units, but independent from the bogies. All spring gear details and also those for the brake gear are fitted with Walter patent hardened-steel split bushes provided with grease lubrication.

All wheel centres are of cast steel with solid balance weights except the driving wheels which have pockets to enable adjustments to be made by lead filling. All the wheels are dynamically balanced in a wheel-balancing machine. Steel tyres are shrunk on the coupled wheels and secured by rivets to conform to the railway's standard practice, although the bogie wheel tyres are secured by Gibson rings. All wheels have flanged tyres.

Expansion joints and ball joints are in accordance with Beyer Peacock's latest practice and particular care in the whole design has been given to make such joints and pipe work easily accessible from ground level. Provision is made at each end of the engine to accommodate the New South Wales standard type buffer with friction draft gear and automatic coupler with screw coupling which are to be supplied and fitted on the arrival of the engines in New South Wales.

BOGIES, BRAKE GEAR AND TANKS

The bogie frames are of box-section in cast steel in one piece with sliding centres and laminated spring side control. The bogie frame castings have been specially designed and manufactured by Beyer Peacock. Ferro-bestos liners are used in the bogie centres which are in turn protected by felt dust shields. Manganese-steel liners are fitted to the pedestals with mechanical lubrication. All bogie axles are fitted with Skefko double row self-aligning roller bearings designed for grease lubrication.

The brake for the engine and train is Westinghouse Australian, A6-ET pattern acting on all coupled wheels of the engine through equalised brake rigging. Air pressure is provided by $8\frac{1}{2}$ in. 150 cross-compound compressor manufactured in Australia. Application is made by the use of an A6-P type pedestal brake valve and the usual controls for this type are conveniently located in the cab. The compressor has its own mechanical lubricator which is of the Nathan, LB3 four-feed type, mounted in position on the smokebox near the compressor.

A hand screw brake operates on the hind unit only from a hand brake with the necessary gearing fixed on the cab back plate. The whole system provides for straight air-brake on the engine in addition to automatic brake for engine and train. The appearance of the locomotive has been enhanced by the careful shaping of the tanks and bunker. These ensure a clear view in both directions from the cab and also add to the general appearance. A common cause of maintenance has been overcome by the use of Beyer Peacock's patent fastening of the tanks to the frame. Under this arrangement special shoes locate the tanks longitudinally and transversely and holding-down bolts are spring-loaded.

This arrangement allows occasional slight deflections of the frame to occur without causing undue stress in the tank structure when traversing uneven track. The tanks and bunker are of riveted construction with the usual fittings which include fill holes at both ends of the locomotive and tank water-level gauge. Particular attention has been given to the shape and design of the bottom of the coal bunker to ensure efficient fall into the conveyor of the mechanical stoker.

LUBRICATION

The lubrication system is particular feature of these locomotives and every effort has been made to provide

an accessible and reliable system to meet modern requirements and to eliminate attention and preparation time by the engine crew. Each unit carries two DV5 type mechanical lubricators supplied by Nathan Manufacturing Co. and also by Davies & Metcalfe Limited. Two lubricators feed engine lubricating oil to the axlebox guides (both coupled and bogie), slide bars, valve spindle guides, reversing link trunnions, reversing shafts and pivot centres.

The other two lubricators feed cylinder oil to the steam chests, piston valve liners, cylinder barrels, steam and exhaust ball joints and the stoker ball and telescopic joints. To meet such requirements a number of four-way distributors is employed. Care has been taken to make pipe joints, valves and other details of the lubrication system accessible from ground level. Ajax grease lubrication, as previously mentioned, is used for the motion, spring gear and brake gear.

CAB AND ACCESSORIES

Every effort has been made to provide the maximum comfort commensurate with efficient operation. The double roof has an inner lining of wood. Ample air doors in the roof and front plate make for maximum comfort during the hot weather and both the driver and fireman have Dunlopillo seats with back rests and arm rests. These seats are adjustable for height and position. There are sliding windows in the cab sides and attention has been given to the provision of food boxes of ample capacity.

The engines are fitted with Stone's electric lighting equipment, current being generated by two 32-V turbo-generators for two 500-Watt Tonum E headlights, and the usual cab lights. Additional points are provided for the illumination of the motion, lubricators, injector overflow, and tank filling holes.

Water gauges conform to the railway company's standard, the one on the left hand being mounted on a special column which is also fitted with three test cocks. The drifting gauge and steam pressure gauge are well positioned in full view of the driver and examination of the illustration will show that he has the reversing gear, regulator and brake handles very closely to hand, whilst keeping him in free position to look forward.

The cab fittings and controls for the mechanical stoker are in accordance with the Standard Stoker Co.'s latest design. Left and right below the fire-hole door are levers which can be used to control the coal outlet on to the table plate. The boiler is fitted with three 3-in.

Ross pop safety valves and has a steam chime whistle operated by cable from the cab. Eight sand boxes in all can deliver sand in front and behind each group of coupled wheels. They have pneumatically operated sand traps and valves supplied by Gresham & Craven Limited. Each engine is provided with four 35-ton screw jacks and two re-railing ramps. The locomotives, designated class "AD-60," are numbered from 6001 onwards and will be finished painted on arrival in New South Wales with black underframes and smokebox, and the boiler and tanks finished in black with a narrow red lining and red buffer beams.

These powerful Beyer-Garratt locomotives of a completely new design for the 4-ft. 8½-in. gauge represent a very definite advance in the detail and general design of this most successful type of articulated locomotive. They embody all the latest developments and improvements dictated by the experience of the builders of this type of locomotive which they have supplied to railways all over the world and, as already stated, incorporate the standard practice wherever it has been possible of the New South Wales Government Railways.

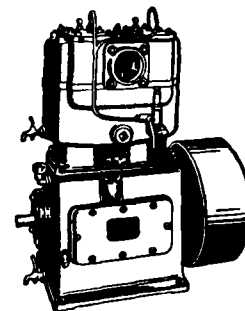
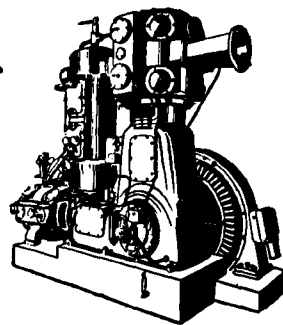
Principal Dimensions

CYLINDERS (4), dia. X stroke	19½ in. X 26 in.
COUPLED WHEELS, dia.	4 ft. 7 in.
BOGIE WHEELS, dia.	3 ft.
AXLELOAD	16 tons
TOTAL WHEEL BASE	97 ft. 8 in.
LENGTH over buffers	108 ft. 7 in.
TOTAL WEIGHT in working order	255 tons
HEATING SURFACE—	
Tubes	2,799 sq. ft.
Firebox, including arch tubes	242 sq. ft.
Total evaporative	3,041 sq. ft.
Superheater	748 sq. ft.
Total	3,789 sq. ft.
GRATE AREA	63.4 sq. ft.
TRACTIVE EFFORT at 75 per cent. boiler pressure	52,550 lb.
TRACTIVE EFFORT at 85 per cent. boiler pressure	59,560 lb.
COAL CAPACITY	14 tons
WATER CAPACITY	9,200 gal.

Atlas Diesel

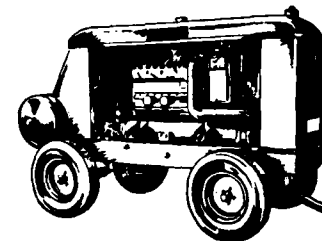
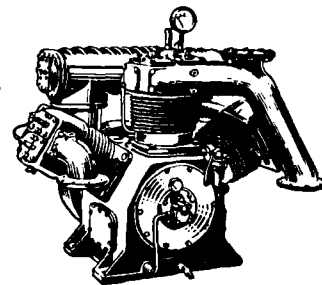
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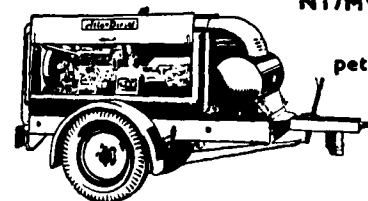
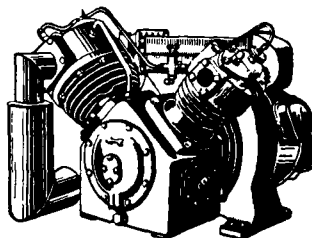
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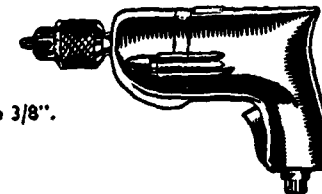


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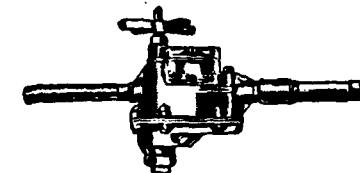
Atlas Diesel

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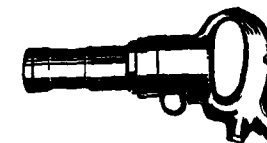
Pistol grip metal drills, up to 1/2". Pistol grip screwdrivers up to 1/4". Pistol grip tappers up to 3/8".



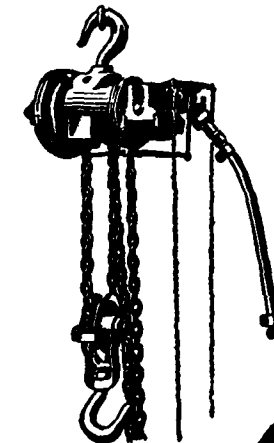
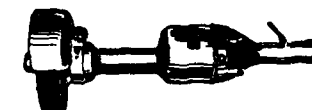
Heavy type drills max. 4".



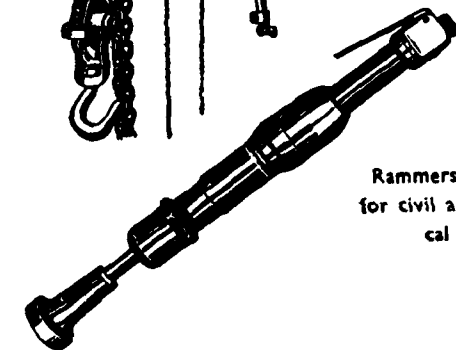
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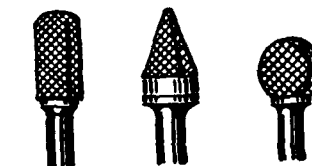
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Special Machines for the Manufacture of Cannonboxes

ONE of the outstanding developments of the present century in locomotive design was the application of Timken tapered roller bearings to all axles of the first anti-friction bearing equipped steam locomotive in 1928.

In the quarter-century which has elapsed since that first application, British Timken Limited of Aston, Birmingham, have been continuously engaged in the manufacture of bearings for steam locomotives, and the fruits of that long experience are to be seen to-day in the highly developed manufacturing organisation for this class of work in their Birmingham factory.

In the case of steam locomotives, more than most other prime movers, the application of anti-friction bearings is bound up with the problem of designing and making satisfactory housings. It was, in fact, the successful solution of the various housing design problems involved which ensured the success of the original Timken-equipped locomotive.

The fact that the housing designs incorporated in the very first Timken-equipped locomotives are essentially those which are considered standard practice to-day, is indicative of the soundness of the original conception.

Of these designs, the housings for the main axle applications, which were of double construction and are known as cannon boxes, represented the biggest departure from what had hitherto been usual practice.

Figures 1 and 2 show typical examples of cannon boxes, and the adjacent Figure 3 shows—for comparison purposes—a typical single box. Single boxes are widely used for all sorts of railway applications other than locomotive main axles.

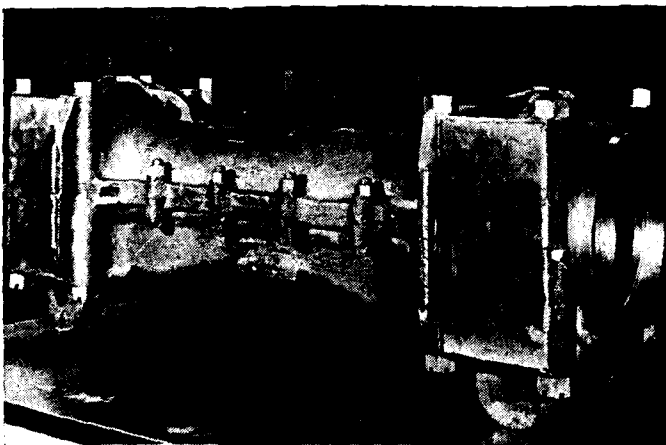


Fig. 1 Typical Split Cannonbox.

It will be seen from a comparison of the boxes shown in Figures 1 and 3 that the cannon box is in essence two single boxes connected together so that the bearings carrying one axle are housed in a unit assembly.

These cannon boxes are either split horizontally as shown in Figure 1, or are designed in one piece as in Figure 2.

Although the manufacture of these boxes involves quite simple operations of boring and facing, milling, drilling, welding and grinding, their form is such that their production on the types of machines usually available for this class of work is slow and very liable to inaccuracies due to repeated settings. That this is so can be readily understood when it is considered that the

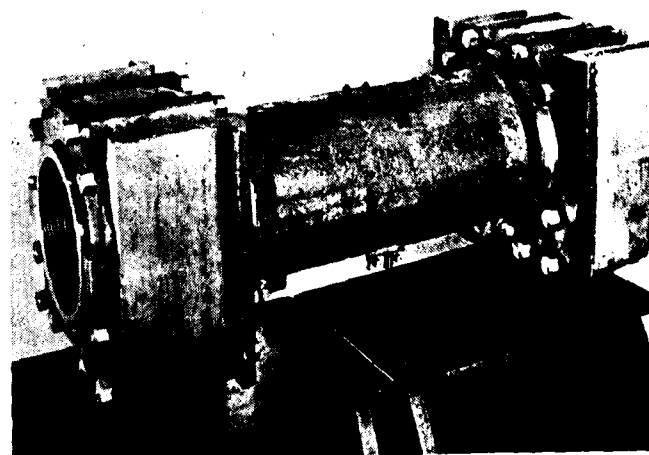


Fig. 2 Typical Solid Cannonbox.

out-of-alignment between the bearing seatings and the guide faces at opposite ends of the box must be held within tolerances which are of the same order as the relatively close limits applicable to the bearings themselves.

In the early days of tapered roller bearing equipped locomotives, when such applications were considered to be more or less experimental, the number of such cannon boxes which had to be produced in this country was relatively small. In such circumstances, manufacture on standard machines by improvised methods could be considered to be part of the development work necessitated by a relatively new application.

Long before the war, however, the number of such applications had increased to a degree which precluded the continuance of such improvised methods, and British

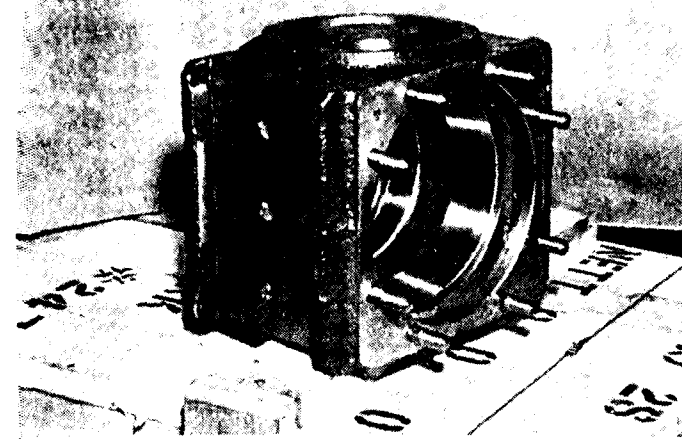


Fig. 3 Typical Single Axlebox.

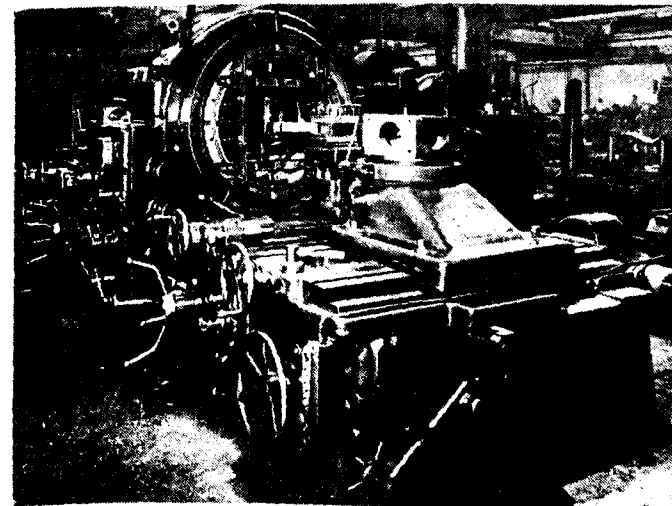


Fig. 4 Double Ended Hollow Spindle Facing and Boring Lathe.

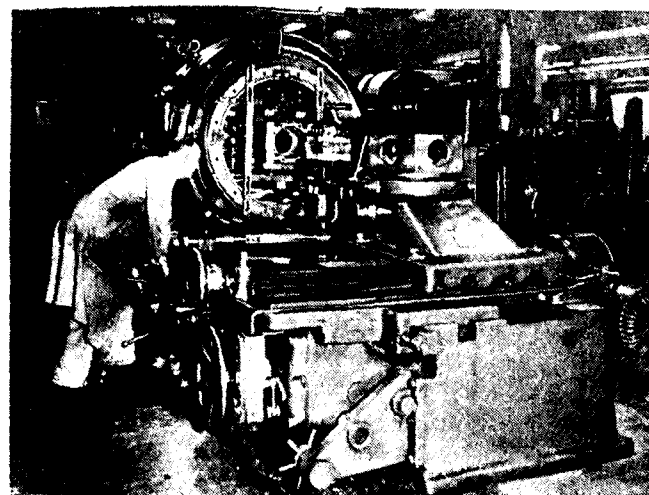


Fig. 5 Cannonbox set up for facing and boring in Double Ended Hollow Spindle Lathe.

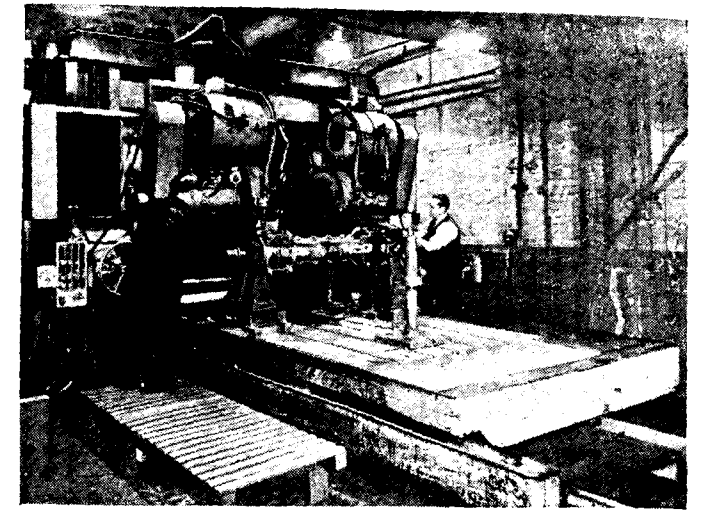


Fig. 6 Grinding Cannonbox Guide Faces on Double Headed Plano-Grinder.

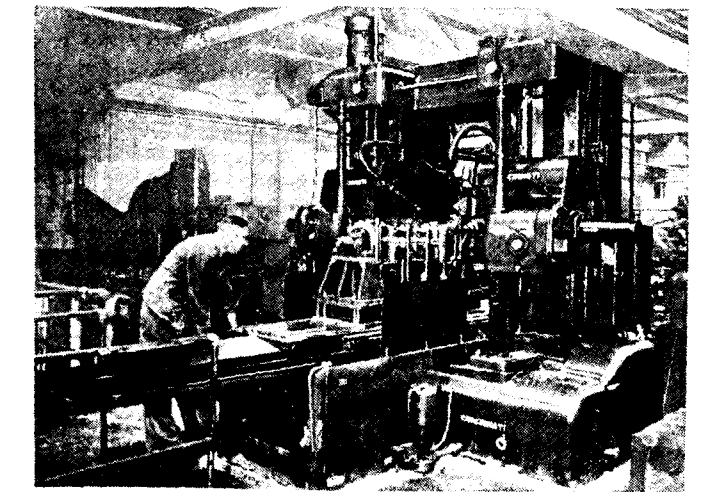


Fig. 7 Cannonbox set up on Special Duplex Miller.

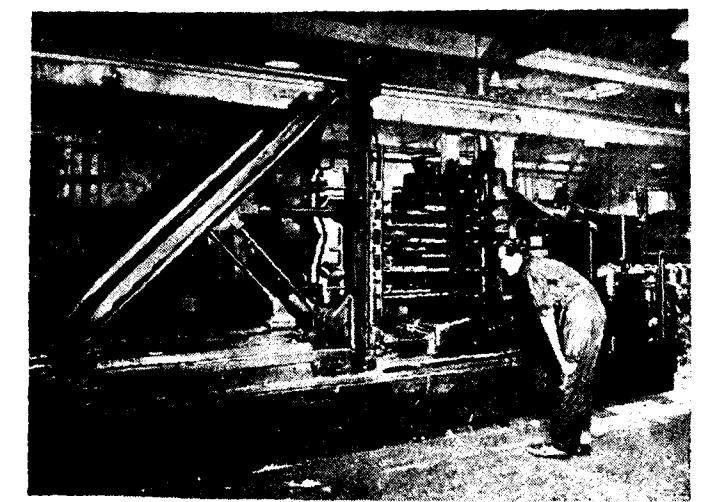


Fig. 8 Half Cannonbox set up on Horizontal Multi-Spindle Driller.

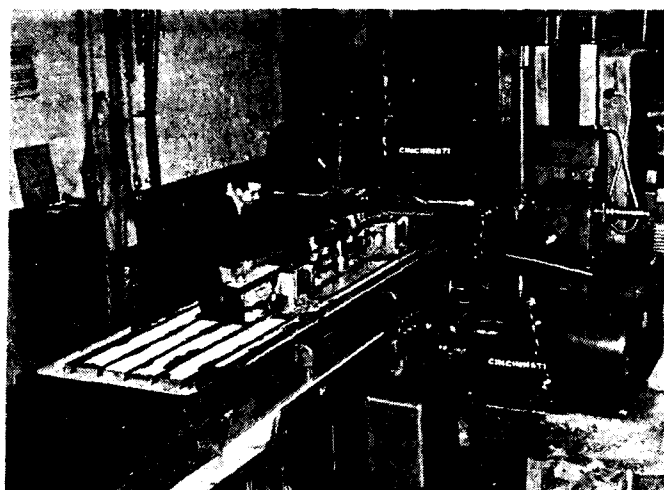


Fig. 9 Joint Face Machining on Horizontal Miller.

Timken Limited established a department specially equipped for the large scale production of boxes of this kind.

The war interrupted both the demand for such housings and new developments in their manufacture. After the war, however, British Timken Limited decided to put into effect certain production methods which early experience had indicated would lead to substantial economies in man-hours.

These methods were based on the conception that most operations on cannon boxes could be carried out on some form of duplex machine which would enable both ends to be machined without re-setting.

It would have been simple to have designed special plant for this single purpose, but the problem was complicated by the fact that cannon boxes are almost always used in conjunction with a substantial quantity of single boxes of similar design. This implied that any special plant should be capable of working economically on both kinds of box. The solution to this problem was found in the machines which are now key units in the system of axlebox manufacture carried out by British Timken Limited, and which will be described in this article.

The first group of operations for which a special machine was devised was the boring and facing of the two ends of a cannon box. In the early stages of production of this class of component, this operation had been carried out on a horizontal boring mill of conventional type. While production in this way is quite practicable, the method is liable to produce misalignment of bores due to inaccurate setting.

It is obvious that, in order to obtain the maximum concentricity of the bores at opposite ends of the housing, some form of turning operation in which the box rotates is desirable. For this reason, an improvised set-up on a large centre-lathe was devised; in this case, however, only one end could be machined at one setting so that production was slow and again liable to inaccuracies.

The final solution was eventually found by building the large machine shown in Figures 4 and 5. This is a double-ended hollow-spindle facing and boring lathe. The bore of the head is large enough to accommodate practically the largest locomotive housing. Boring and facing are carried out simultaneously on both ends of the box, so that not only is alignment ensured but production time, as compared with the other methods mentioned above, is halved.

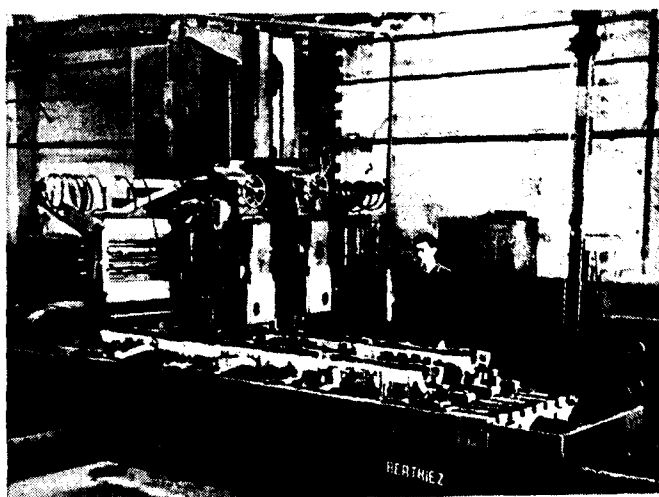


Fig. 10 Joint Face Machining on Planer.

This machine can also be fitted with a face plate on the ends of the hollow spindle and used as a conventional boring and facing lathe on which single axleboxes could be produced. It therefore meets the requirement of being a satisfactory method of producing cannon boxes whilst being readily convertible to the production of single boxes.

Although this is a double ended machine, it has been found to be quite easy for one man to operate it with tools working on both ends of a box. It is powered by a 70 h. p. motor and has a very wide speed range, so that it can handle a very wide range of work.

The grinding of manganese liners and of joint faces of boxes presents special problems. In the case of single boxes, these operations are carried out on open-sided surface grinders of conventional design. Although it is usually practicable to grind the joint faces of cannon

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boxes on such machines, it is generally difficult to devise a practicable set-up for the grinding of the guide faces.

The solution of this production problem led to the evolution of the machine shown in Figure 6. This is a very large plano-grinder fitted with two wheel heads so arranged that either two manganese joint faces on the same side of a box or the joint faces of two half-boxes can be ground simultaneously. The table of the machine is 10 ft. X 6 ft. and the wheel heads are designed to carry 24" diameter X 5" wide wheels. The table can accommodate the largest type of box under a full size wheel. Duplicate controls are provided on each side of the machine, and each wheel head can be operated independently of the other. The grinder is normally operated by two men working as a team.

With this machine, the grinding of guide faces on cannon boxes can be carried out quickly and accurately with the set-up shown in the Figure. The machine is equally effective when used on single boxes.

Figure 7 shows another special machine used for the milling of horn guide faces. This operation was initially carried out on a conventional duplex-miller so that each end of the box required a new setting. This method proved costly due to the setting time involved. The machine shown in the Figure is a duplex miller with heads designed to feed either upwards or downwards, and with a hydraulically-operated traversing work table. The box is mounted horizontally, and milling is carried out on one end at a time with the cutters fed vertically. The table dogs are set so that the box can be traversed by the amount of the horn guide centre distance. In this way, both ends of the box can be duplex milled without re-setting.

This machine is equally effective when used on single boxes and has the advantage that a box can be set up whilst another is being milled.

The drilling of these cannon boxes, especially where split boxes are involved, is a slow and costly operation if carried out on conventional machines. Figure 8 shows a multi-spindle driller devised for this operation. This is a 12-spindle horizontal machine with automatic hydraulic relieving mechanism for the head. It is fitted with an adjustable jig on which either half-boxes can be mounted vertically or solid boxes mounted horizontally. Figure 8 shows the set-up used when drilling a half-box.

Since the total number of holes in a box is seldom less than 16, half-boxes are generally drilled in two settings. The eight holes at one end of the box are dealt with first as shown in the photograph. The box is then turned round on the jig and the other holes drilled in similar fashion. The jiggling arrangements are such that the half-box can be located accurately on each setting. This multi-driller is equally effective on single boxes.

These four machines are special conceptions devised to meet the particular conditions outlined in the first part of this article.

The machining of the joint faces of the split type of cannon box is carried out on machines of conventional type either by milling, as shown in Figure 9, or by planing, as shown in Figure 10. Due to its flexibility and independence of expensive tooling, a planer is very satisfactory for this operation, but the usual design of machine has the drawback of being relatively slow when compared with a miller.

The machine used by British Timken Limited, shown in Figure 9, overcomes this disadvantage by being designed to cut both ways. This has provided a fast and flexible method of handling this particular operation.

The machines described in this article are part of a special department for the production of locomotive bearing housings in the Cheston Road works of British Timken Limited.

Prior to the establishment of this department, locomotive bearing housings of the types which are now standard, both in this country and abroad, had of necessity to be drawn from sources which had no special facilities for the precision production of such components.

Since double housings of the cannon box type are now proving to be an ideal means of accommodating anti-friction bearings in diesel and electric, as well as steam, locomotives, British Timken Limited believe that, in providing manufacturing facilities of the type described in this article—facilities which are probably unique of their kind—they have made a most valuable contribution to the locomotive building industry of the country.

Diamond Tools for Abrasive Wheel Truing

INTRODUCTION

Industrial Diamonds are used in the production of almost every manufactured article.

Table I is intended to show in the very broadest sense, the different operations on which diamonds of various size ranges and types are used.

TABLE I

Broad Classification

USE	TYPE OF DIAMONDS	SIZE RANGE CARATS
Abrasive Wheel Truing	Roundstones, Octahedrons, Pieces, Ballas, Brazil Carbon	1/10 — 15
Rock Drilling	Drill Bortz, Congo, Ballas, Carbon and Boart	1/200 — 2
Machining non-ferrous metals, plastics and refractories	High grade flat crystals and Cleft Pieces	1/2 — 4
Wire Drawing	High grade Octahedrons and flat crystals with clear centres	1/10 — 2
Hardness testing	High grade crystals	1/5 — 1/3
Glass Cutting	Vitriers	1/80 — 1/5
Gauging	Roundstones, Octahedrons, Cleft Points and Flats	1/20 — 1/2

1 metric carat = .2 gramme (approx. 1/150 oz.)

Abrasive Wheel Truing

The present article will deal only with diamond uses under this heading.

Most diamonds for this purpose are used as mined in their natural shape and condition. As will be seen from the above table, there are several different diamond types and a wide size range suitable for this work. In addition, there are many qualities within each type. In deciding the type, size and quality of diamond to be used in truing a given wheel, it is sometimes supposed that only wheel dimensions need be considered. This is not so as all of the following factors may effect diamond selection :—

Wheel	Diameter	Profile	(a) Plain
	Width of face		(b) Stepped
	Grit		(c) Thread forms
	Grade		(d) Other forms
	Bond	Machine	Type i. e., centreless, plain, surface, tool and cutter
	Abrasive		Maker
			Condition
		Work	Material to be ground
			Accuracy required
			Surface finish
		Operation	Toolroom standard
			Skilled Grinder
			Semi-skilled Operator
			Unskilled Machine Minder
			Whether shift working is in force

There is no formula yet devised to correlate all these factors to the range of diamond types, qualities and sizes available.

Table 2 shows examples of diamond specifications in relation to specific jobs. It would, however, be quite incorrect to infer from this that the specifications would

hold good for the same job under any conditions other than those which obtained in these examples. The size ranges quoted are for new tools. Following successive resetting, the diamonds should in most cases work satisfactorily down to 50% of the mean size stated. If however, more suitable work is available they should be transferred to it after a loss of, say, 25% to 35%.

TABLE II

EXAMPLE No.	TYPE OF GRINDER		WHEEL		DETAILS		DIAMOND SPECIFICATION	
			APPROXIMATE		APPROXIMATE		APPROXIMATE	
			DIA. Ins.	FACE Ins.	GRIT	GRADE	WEIGHT Cts.	DESCRIPTION.
1.	Plain		20	2	60	M	2-3	Medium quality crystal or piece
2.	Surface		7	1	46	K	$\frac{3}{4}$	- ditto -
3.	Internal		2	1 $\frac{1}{2}$	60	L	$\frac{1}{2}$	Good quality Crystal with well defined points or wheel type magazine tool
4.	Centreless	Work Wheel	24	6	80	L	3-5	Good quality crystal or ballas type
		Control Wheel	12	6	120	Rubber Bond	1 $\frac{1}{2}$ -2	Good quality crystal with well defined points or multi-point type S6
5.	Centreless on fairly open form work	Work Wheel	24	6	46	K	Special Blade Truer Type 333R	
		Control Wheel	12	6	80	L	Special Blade Truer Type 222V	
6.	Universal on circular Form Tool Grinding		7	$\frac{1}{2}$	100	G	Special polished Chisel Truers on Diaform Pantograph Forming Attachment	

It will be seen that in examples 1 and 2, only single point truers have been mentioned. FIG. 1 illustrates conventional types as well as indexing type tool holders. On most similar jobs such tools would be the best but where for any reason truing tools are likely to be abused on such work, the "impregnated", "multi-point" or "in-line" type of tools should be substituted. For example, a suitable alternative would be the Diatuf type A. 300R. The cutting head of this tool consists of 18 small whole diamonds of equal size set in a regular pattern of 4 layers. The matrix consists of tungsten powder and an alloy binder. This matrix forms a chemical bond with the diamonds and retains them throughout their useful life. Such a tool will stand much more abuse than a single point truer and needs no resetting.

For example 2, a smaller tool in the same range would be a suitable alternative.

An alternative is given in example 3. This wheel type tool is illustrated in FIG. 2. In order to prevent deflection of the small spindles of internal grinders using wheels up to 2", it is necessary that the diamond truing tool shall exert a minimum pressure. To do this it is essential that a sharp point be maintained on the tool.

The wheel type tool contains eight small diamonds, each set with a good point presented for work. As each point is worn the next can be brought into use.

The simple action of loosening the Allen Screw, turning the Wheel and re-tightening the Allen Screw, is all

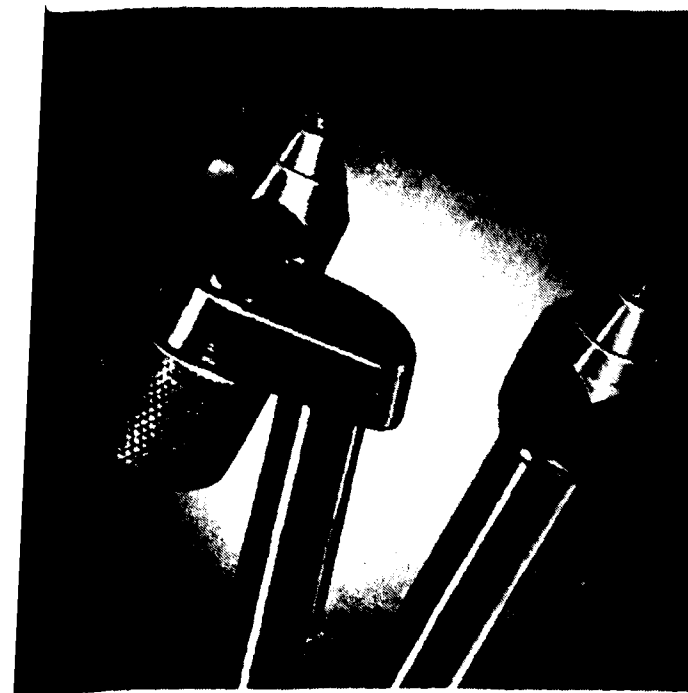


Fig. 1

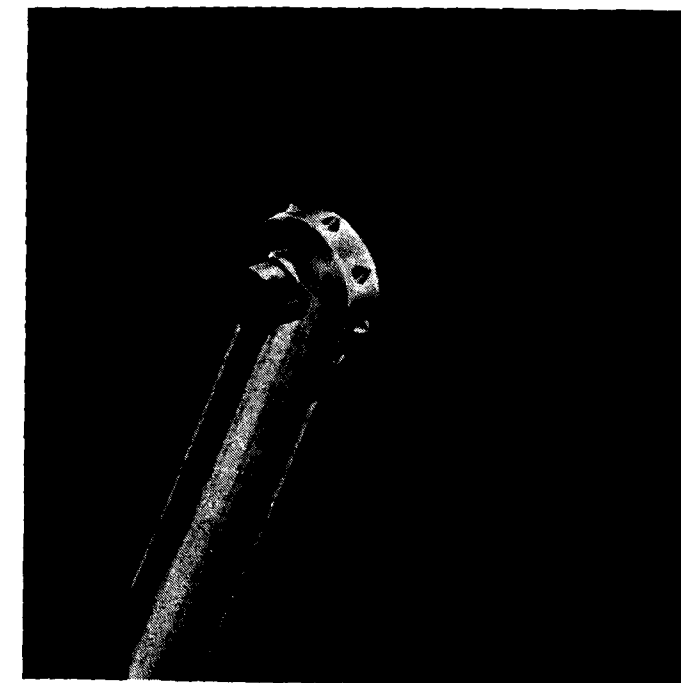


Fig. 3

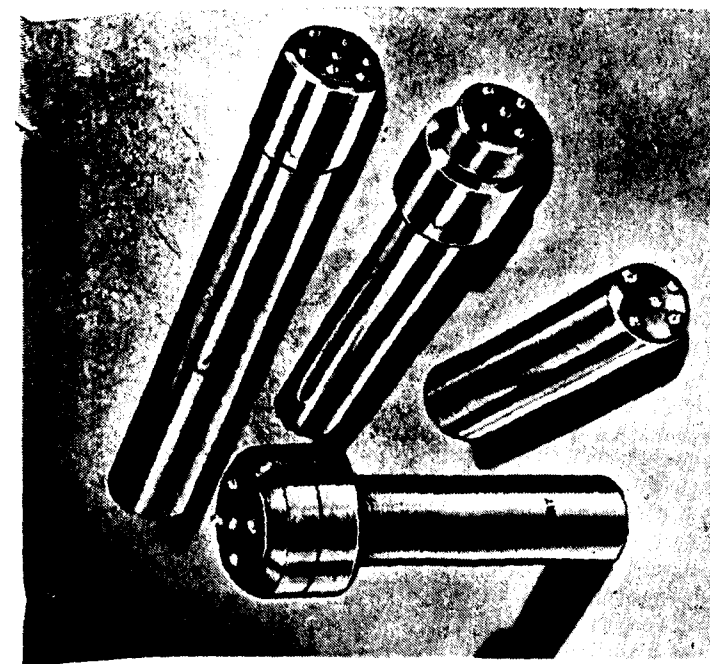


Fig. 2



Fig. 4

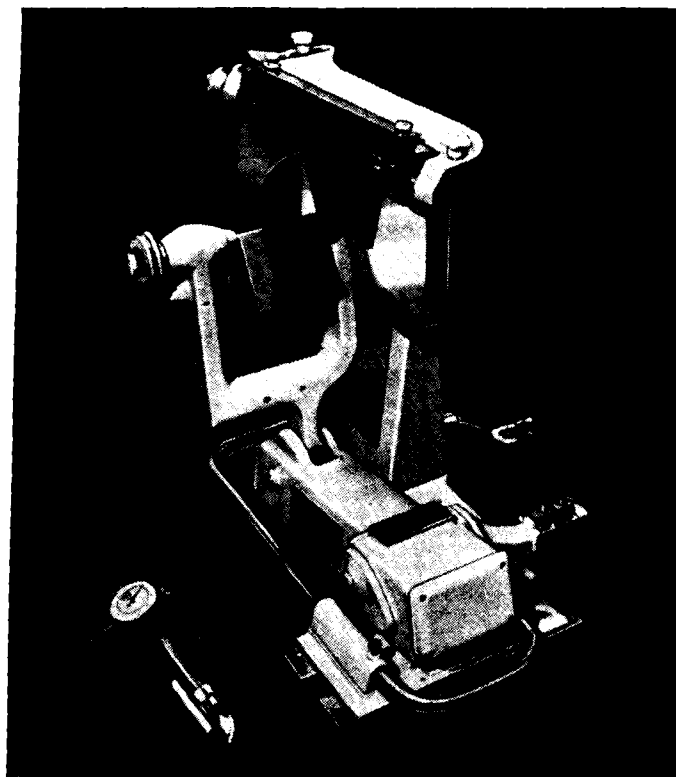


Fig. 5

that is needed. No resetting is required and the maximum use is made of the diamond content of the tool.

An alternative for the work Wheel in example 4 would be an "impregnated" type tool similar to that described for examples 1 and 2. The construction of such a tool would be identical but it would have a heavier diamond content.

A lighter type again would serve on the control wheel if it was of vitrified bond. The tenacious rubber bond, however, requires a sharp pointed diamond. The wheel type presenting one small diamond to this comparatively large wheel would, however, wear rapidly.

The S6 tool illustrated in FIG. 3 is designed to provide the advantage of the sharp point with the wearing qualities of a larger diamond. The head can be adjusted around the centre provided by the retaining Allen Screw. When new, a slight offset on the head brings only one of the end diamonds in contact with the wheel. As the point is dulled in use, the point of the adjacent diamond gradually comes into use and retains the free cutting properties of the wheel. The process is continued until all six points have become too dulled for further use.

For taper or very open radius production form grinding, a single point truer can be satisfactorily used. Example 5, however, pre-supposes that the form is so complex or has other characteristics that prevent the satisfactory use of such tools. The limiting factor usually lies in the increasing width of diamond cutting face as the tool continues to be used. Each Dianyf blade type truer had a specified maximum width of diamond cutting face which is maintained throughout the life of the tool. FIG. 4 illustrates the 333 range of blade tools. The small diamonds are set in the tungsten blade by a patented powder metal process. The result can be likened to a sandwich of which the "bread" is tungsten matrix and the "meat" a layer of diamonds.

The tool requires no resetting and, in fact, need not be re-adjusted in the machine during its whole life. In order to correct the normal "drag" angle on truing tool sockets, the blade is offset so that its centre line coincides approximately with the wheel centre line. The development of the blade type truing tool has greatly facilitated production form tool grinding not only on centreless but on any grinder which can be equipped with a suitable unit to control the path of the truing tool.

Normally, however, the methods available, whilst quite adequate for production work are not sufficiently flexible or accurate for tool room work. The form grinding of punches and dies, as well as flat and circular form tools, has become standard practice. The Diaform Pantograph Wheel Forming Attachment was developed to provide the required accuracy where the form grinding could be done of a normal surface grinder or universal grinder of the Brown & Sharp No. 13 type. FIG. 4 illustrates one of the Diaform range of Attachments.

The sequence of operations required to produce a ground form with such an Attachment as mentioned in Example 6 is:—

- By normal plotting and filing methods, cut on a 3/32" Mild Steel plate a X10 copy of the required form.
- Attach this template to the carrier of the Attachment.
- Select the largest standard Chisel diamond profile that can be accommodated in the form. Normally the choice lies between chisel forms of 40° included angle and .005" radius or 60° included angle and .010" radius. Set up this chisel tool and roughing tool on the truing arm.

- Set up the Attachment on the grinder with the wheel in the surface grinding position.
- With the stylus held in the highest part of the template form, advance the roughing tool until it contacts the wheel. By advancing the cut in increments of .001" and traversing the stylus across the template at each advance, the rough form is soon produced on the wheel. The final accuracy is imparted to the wheel by centring the finishing diamond chisel in relation to the wheel and continuing the traverses across the wheel face.
- Rotate the grinding wheel through 90° to the cylindrical grinding position and set up the blank circular tool.

- Grinding the form from the solid fully hardened steel blank. In the case of deep forms it is sometimes advisable to retrue the form before making the final grind.

The procedure is simplified, of course, in the case of punches and dies or flat form tools where the grinding can be undertaken on a normal surface grinder.

The chisel diamonds for these Attachments are set by powder metallurgy and the flanks are ground to the required included angle. The tool is held in a jig attached to the conventional diamond polishing lap. When this operation is complete, the jig is transferred bodily to a special radius grinding machine on which the forming of the diamond radius is optically controlled.

(Continued on page 38)



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The White-Metalling Process

Methods Employed for Railway Rolling Stock and Other Bearings

CONSIDERABLE developments have taken place of late years in the method of white-metalling the bearings of railway rolling stock and bearings of a similar type, and today pressure casting is rapidly superseding the old method of pouring by hand the white-metal strip forming the bearing surface, with its attendant drawbacks of blowholes and porous material. The photograph Fig. 1 shows a couple of interesting combined plants for such pressure casting made by the Monometer Manufacturing Co. Ltd., 115-116 Strand, London, W. C., which are in use at the Shildon Works of the British Railways, where the production of bearings is in the region of 1400 per week.

A typical bearing for rolling stock is shown by Fig. 2, the most usual sizes being 9" long by $4\frac{1}{2}$ " diameter, 9 x $4\frac{1}{2}$ " and 10 x 5", and this drawing shows the dovetailed slot forming a secure fixing for the inserted white-metal strip. An analysis of the metal used for the main casting is: Tin 6-8%, Lead 1-3%, Zinc 4-6%, Nickel not more than 1%, and Copper remainder. For the tin base white metal used for the lining of the brasses, the analysis is: Tin 56%, Lead 30%, Antimony 11%, and Copper 3%.

MACHINING

The rough casting is first shot-blasted, ground on a disc grinder to gauge, and the back milled on a vertical miller (speed 360 r. p. m., and feed 12" per minute). In this operation, the bearing is located from the inside face which is later to be filled with white metal, this

location determining the thickness of the brass casting, which is important as controlling the amount of white-metal required for the actual pressure casting. The casting is next bored and faced on a special machine, the pieces being mounted in a jig and machined in pairs (spindle speed for boring 392 r. p. m., and feed .016" per revolution; speed for facing the ends 132 r. p. m. with hand feed). The next operation is to drill three small breather holes in the back of the casting to allow for the escape of air when pressure casting. This is done on a driller with a special head mounting three drills (spindle speed 1150 r. p. m., and feed .005" per drill rev). The dovetailed recess already mentioned is finally machined on another vertical miller equipped with a rose-bit cutter, tungsten tipped.

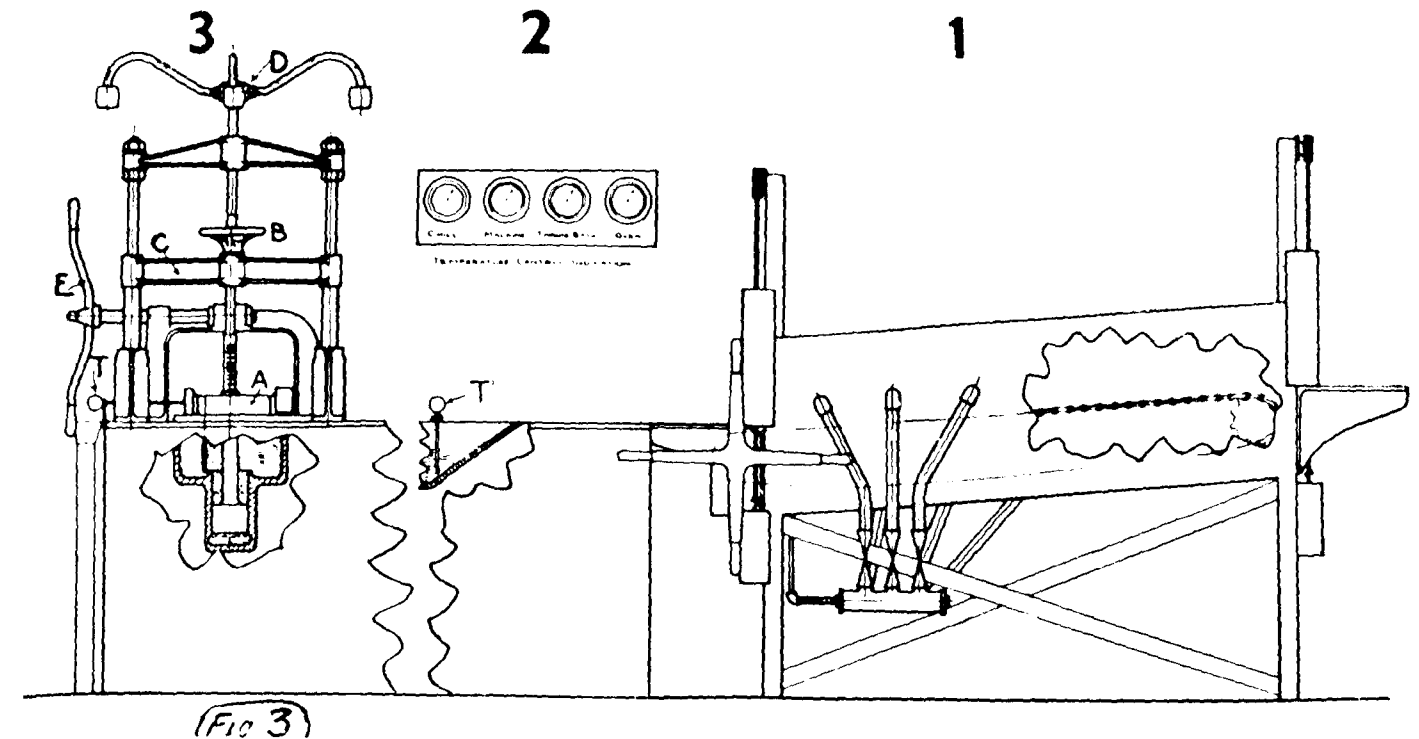
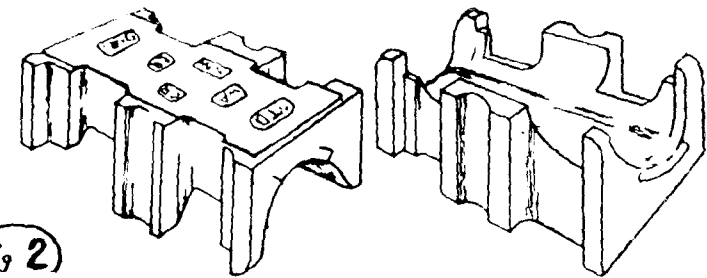
WHITE METALLING

The design of the Monometer plant for white-metalling can be followed by reference to the sectional view Fig. 3, from which it will be seen that a plant comprises three units, (1) the preheating oven, (2) tinning bath, and (3) the pressure casting machine. All these are heated by natural-draught burners operating on gas at ordinary mains pressure, each set of burners being supplied from a pressure-equalising chamber, and each of the three units comprising the plant being under separate automatic control for temperature.

The brasses are first painted on the surfaces which have not to be tinned with a mixture of French chalk and water to which a little isinglass has been added to

Such tools consist of a metal compact moulded on one or more faces to the form required and impregnated with small diamonds over that area. This forming tool can be blamped into the position normally occupied by the workpiece and traversed across the wheel as if it was the component being ground. It is fed into the wheel in increments of .002"—.003" and soon transfers the form on the diamond tool to the wheel maintaining an accuracy of within a few thousandths of an inch.

It will be appreciated from this summary of the uses of diamond for abrasive wheel truing, that present practice does not confine the user to the use of the conventional single point wheel true.



(Continued from page 37)

Similar production methods are used in manufacturing chisel truers for other means of form grinding including gear and thread grinding.

In some cases the initial roughing out of the shape on a new wheel can be facilitated by the use of a Diatuf Impregnated Form Tool.

This, however, is only an economical proposition when:—

- (a) It is a fairly wide, peep form.
- (b) The job is likely to be repeated often enough on new wheels that the total roughing out time will be appreciable.

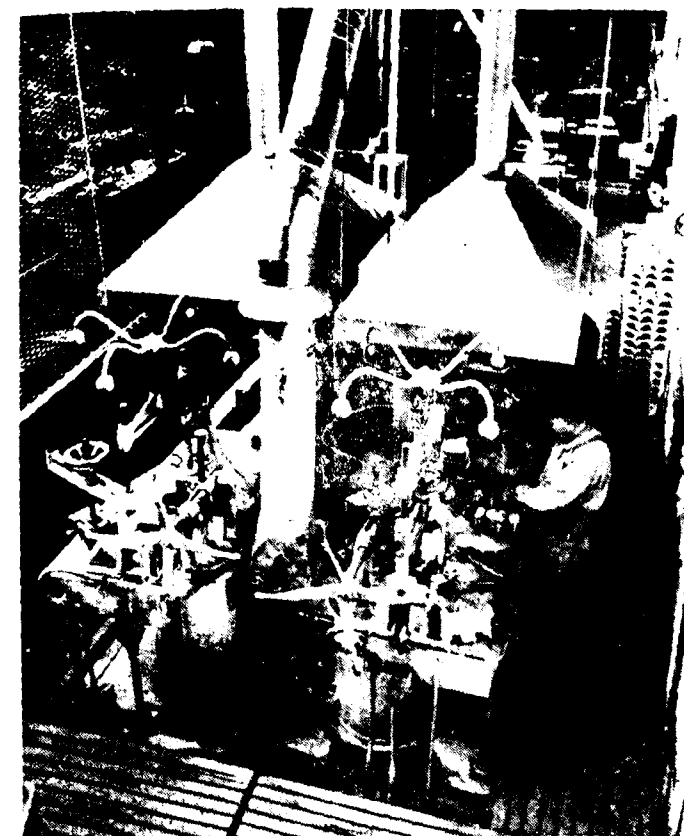


Fig. 1



Fig. 4

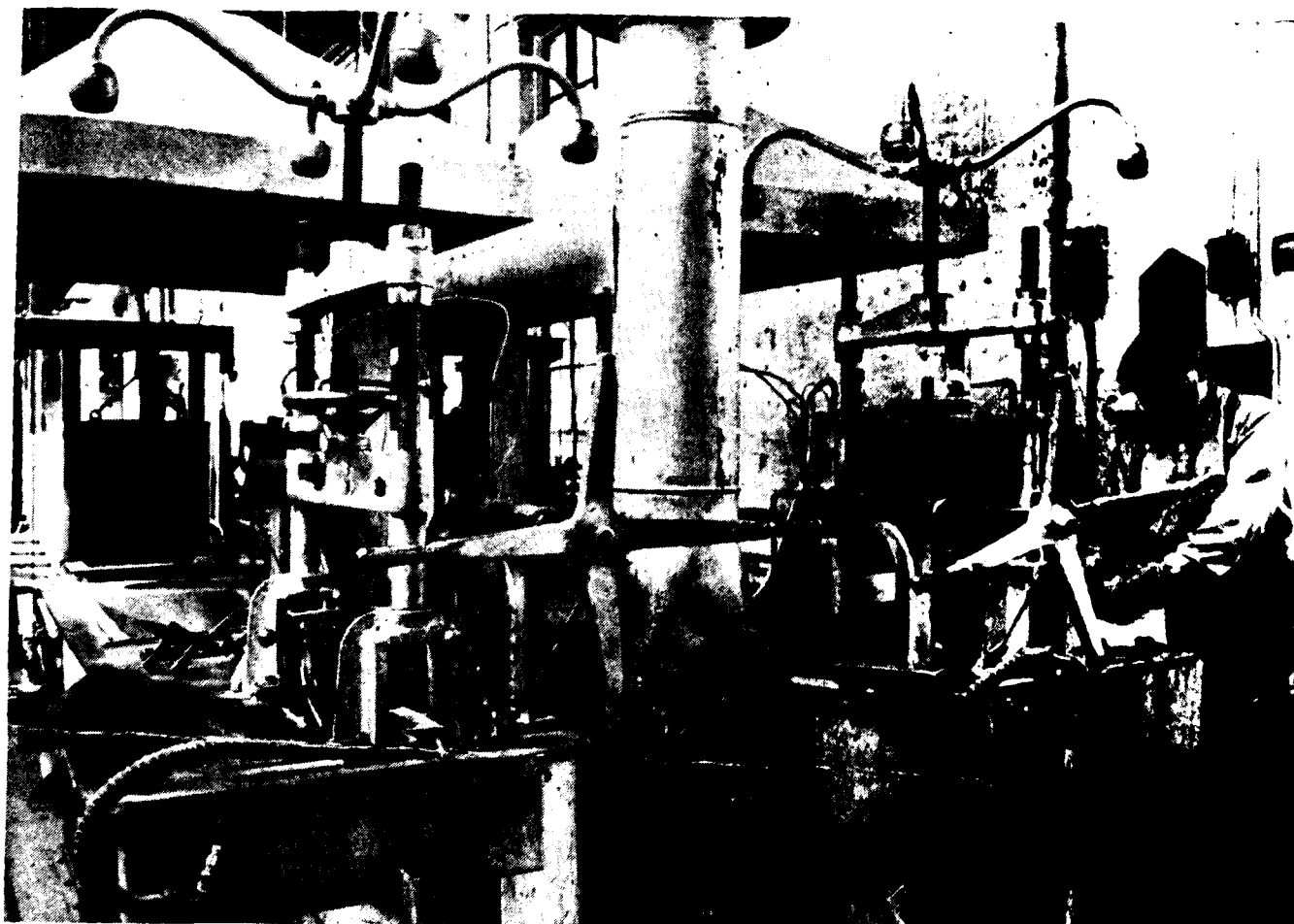


Fig. 5

prevent rubbing off, and then placed in the preheating oven, which is equipped with a chain conveyor hearth operated by handwheel at the discharge end, the oven having a capacity of fourteen brasses. In this they are raised to a temperature of 650 degrees Fahr., fresh brasses being inserted through the lifting door at the feed end to replace the heated castings as they are discharged at the exit end on to the work-table. Here, the dovetailed recess is brushed with Baker's solution (a cleaning and fluxing solution), and any grit or sand removed, after which the casting is submerged in the tinning bath (2), this being automatically maintained at 450 deg. Fahr. ("T"), with an average gas consumption of $1\frac{1}{2}$ therms per hour. When it has acquired this temperature, the casting is removed by tongs and again brushed, and then passed along to the pressure casting machine (3) and placed in the chill or die "A" carried on the pivotted bridge arm "C" which swings over and locates the brass in the chill over the casting nozzle, where it is finally locked by the large upper handwheel "D", the brass being clamped in the lifting box by a small hand lever. White metal is then forced into the dovetailed recess by means of the handwheel "E" at the side of the machine which operates the plunger in the

melting pot through rack and pinion. The brass is now lifted from the chill or die in the lifting box, swung over the working table, and dropped out by operating the quick-release hand lever. No subsequent machining of the bearing face is required. The pressure casting machine has a capacity of 200 lb. of white-metal, and is suitable for metalling bearings up to 20 lb. in weight with an output up to 25 lined bearings per hour and a gas consumption of 1 therm hourly.

The chill (or die) used is of mild steel, fitted with lifting box, and is water-cooled, with provision for the use of an endwise indicating pyrometer "T" for taking the chill temperature, which is maintained at 160 to 200 deg. Fahr.

The sequence of operations and the design and layout of the plant can also be followed from the photographs of the British Railways equipment. In Fig. 1 pivotted bridge arm on the left is open ready for the insertion of another bearing in the chill. Fig. 4 shows the oven with a bearing just discharged ready for immersion in the tinning bath, and Fig. 5 is an end view of the pressure casting machines.

The Role of Aluminium in Rail Coach Construction

By M. S. Woo

TRANSPORTATION is consistently one of the largest users of aluminium. The reason lies in the fact that aluminium has so much to offer to the industry. Aluminium is light in weight, has excellent corrosion resistance and its price invariably makes this material cheaper in the long run.

For rail coach construction, the principal fields of application of aluminium are as follows:

1. Miscellaneous fittings and equipment
2. External and internal panelling
3. Framework
4. Aluminium coach of new design

MISCELLANEOUS FITTINGS AND EQUIPMENT

Aluminium fittings such as luggage racks, miscellaneous hardware, hat and coat hooks, etc. are extensively used abroad. Its use in Indian Railways will gradually increase too since aluminium possesses

adequate strength for these articles and is considerably lower in cost when compared to other non-ferrous metals.

Aluminium window frames and louvres are invariably used in the latest coaches built abroad. Broad gauge coaches now being imported from Switzerland and metre gauge coaches imported from Germany or made in Jessops also use the same material. Such aluminium parts do not need painting and will not warp when exposed to the harsh climatic conditions of India.

Aluminium roof tanks for water storage are also used in the coaches mentioned above. Since aluminium does not rust, the tanks last much longer than galvanized steel ones. The public is also assured of clean water at all times. There are over 2000 of such tanks being used in Indian Railways now.

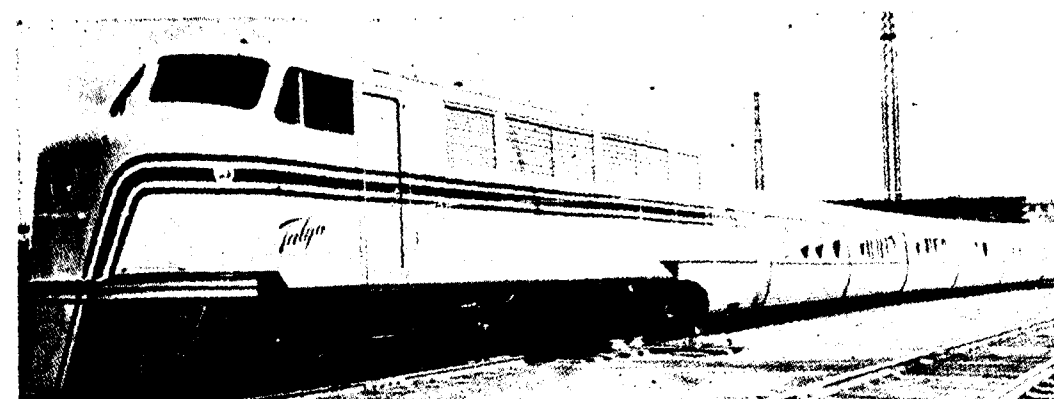
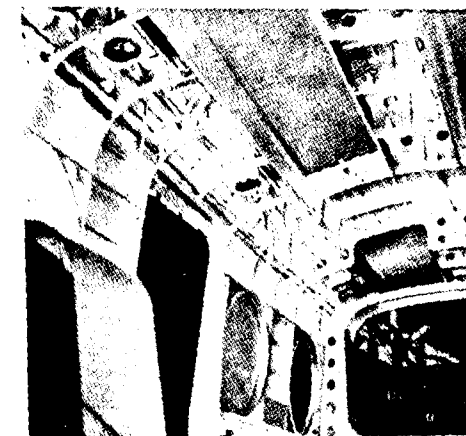
EXTERNAL AND INTERNAL PANELLING

The advantages of aluminium panelling are as follows:

(Right) Some of the framing details of the A.C.F.-Talco equipment unit. Aluminium alloys in the form of extrusions, sheet and castings are used almost exclusively in the construction of the coach units.

(Below) The demonstration A.C.F.-Talco train consisting of a locomotive, a baggage unit and a coach of five units. In this dramatic development all-aluminium construction has resulted in the coaches being only one-fourth the weight of conventional steel stock.

(Patentes Talgo and American Car and Foundry Company).



1. As aluminium does not rust, panels will last the life of the coach. This characteristic is also responsible for low maintenance cost.

2. Light weight. For panelling medium strength aluminium alloy (INDAL M57S) of the same gauge as steel is used. Since aluminium is one-third the weight of steel, this means a saving of about 2 tons for a meter gauge coach. This light weight is especially important in the following special type of coaches.

- (a) Air conditioned coaches, restaurant and annapurna cars where the equipment is so heavy that the equipment is so heavy that the underframe has to be strengthened at high cost.
- (b) In suburban electrified stock. London Transport ran actual tests on electric consumption of steel and aluminium trains. The former weighs 148 tons and the latter 127 tons. The saving in electric energy on the aluminium train is 12.4%.

FRAMEWORK

Aluminium structural sections are made from the extrusion process. In the beginning of 1955 the first extrusion plant specially designed for aluminium will be put into operation by the Indian Aluminium Company, Ltd. With an indigenous source of aluminium structural sections assured, the possibility of using aluminium framework for coaches should be investigated.

Since structural design of aluminium differs in some respects with that of mild steel, a brief outline of designing in aluminium is given below :

For framework, a medium strength aluminium alloy, 51S-WP is used. The American Society of Civil Engineers has fixed a design stress of 15,000 lbs./sq. in. for this type of alloy. This applies to stresses in bending and in tension.

For compression, another factor comes into play—the Elastic Modulus. The figure is 10,000,000 lbs./sq. in. for aluminium as against 30,000,000 lbs./sq. in. for mild steel. To compensate for this, aluminium sections should be deeper than the corresponding steel members.

For coach frames where the members are often subjected to both tensile and compressive stresses, it has been found that an increase in depth of 20—25% over that of a steel member generally gives satisfactory results.

The weight ratio of aluminium to steel in this case is 40—45%.

ALUMINIUM COACH OF NEW DESIGN

It has been estimated that a steel coach of conventional design has the following division of weight components :

Body structure	15%
Body inside finish	17%
Underframe structure	18%
Underframe mechanical equipment	19%
Bogies	31%

Taking the weight of a steel coach as 30 tons, the body and underframe structure amounts to about 10 tons. If aluminium structure is used, a saving of 5 to 6 tons is about the maximum that can be obtained. If further weight reduction is desired then a new design becomes necessary.

An outstanding example of such a design is the Talgo train. The coach design is unique. They are four feet less in overall height than conventional ones ; the centre of gravity is two feet lower and the floor is only 18 inches above the rail. Each coach has only one axle. This axle is placed at the rear of each unit. The front is supported by the rear of the preceding coach thus presenting a series of coupled trailers. By using aircraft type of aluminium alloy and construction, a train seating 64 passengers weighs only 37,400 lbs. This is about one-quarter of the weight of coaches of conventional design and providing the same kind of air condition and dining services.

This train has been in service in Spain for about two years now. It runs between Madrid and the French-Spanish border town of Irun, a 400-mile route of steep grades. The best time for conventional type of train over this route is 13 hours. Talgo train makes it 8½ hours. Surprisingly this increase in speed is obtained at a reduced operation and maintenance cost. Exact figures are not available yet but one official of the Spanish National Railroad estimates that if they were to replace all of their existing equipment with Talgo trains, a saving in excess of 66% may be obtained.

In conclusion it may be stated that aluminium has a very promising role in rail coach construction. Its higher initial cost can be amply justified by its longer life alone. If lower operating and maintenance cost is taken into account, then aluminium occupies a pre-eminent position among all construction materials.

New Locomotive Wheel Centre Invented in Australia

A new design of wheel centre has been developed in Australia in the Locomotive Section of the Rolling Stock Drawing Office, Victorian Railways, in conjunction with Mr. F. C. Paynter, of the Steel Company of Australia Pty. Ltd. It is known as SCOA-P.

The design possesses quite a number of important advantages. Although the wheel centre is lighter in weight, tests have proved that it has a much greater lateral strength compared with the conventional spoked type.

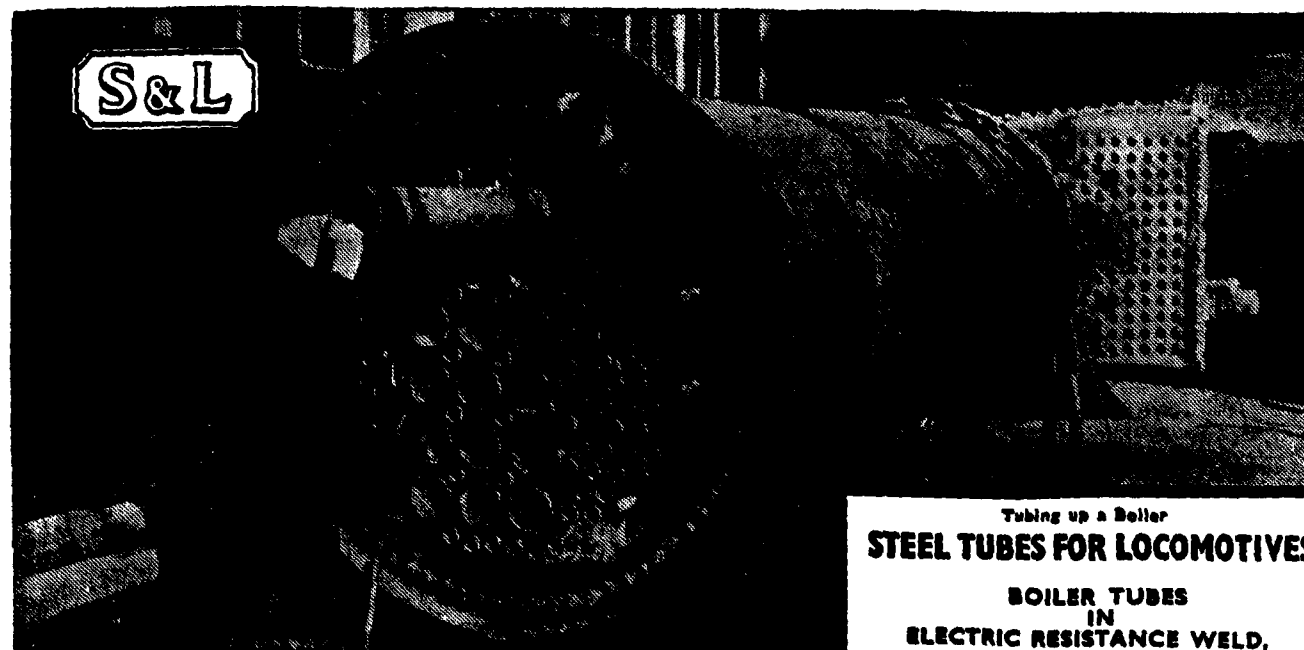
The usual shape of spoke features a heavy cross section. The solid sections at the boss and rim, when they meet the cross section, give rise to segregation of the metal and weakening of the casting. This results at times in failure in service, especially in wheels of the larger diameter.

The disabilities are eliminated in the SCOA-P wheel. This has a thin-walled V-shaped section for the spoke, and a channel section for the rim, both having bulbed edges. The shapes of spoke and rim facilitate moulding operations also, and produce a clean sound casting. Wheels of the new design yield and bend but do not break, state Victorian railway engineers.

World patents for the SCOA-P wheel are held by the Steel Company of Australia Pty. Ltd., and the company has already granted manufacturing licences to organisations in Queensland, Australia, to the United Kingdom, Belgium, Italy and West Germany. Applications for licences are at present being considered from manufacturers in Spain, Norway, Sweden and Denmark.

SCOA-P wheel centres have been delivered, or are on order for rolling stock in many Australian States and in oversea countries.

The East African Railways recently placed orders for 46 Class 31 locomotives, and 26 Class 30 locomotives, and have specified SCOA-P wheel centres. With these contracts the total number of SCOA-P wheels in use will have reached approximately 6,200 mark. This type of locomotive coupled wheel was first introduced on the Victorian Railways R class locomotive, and has been adopted for the 60 J class locomotives now being manufactured for the Victorian Railways by Vulcan Foundry, Newton-le-Willows, Lancashire, England. The first J class locomotive arrived early in March, and progressive deliveries are being made at the rate of two a week.



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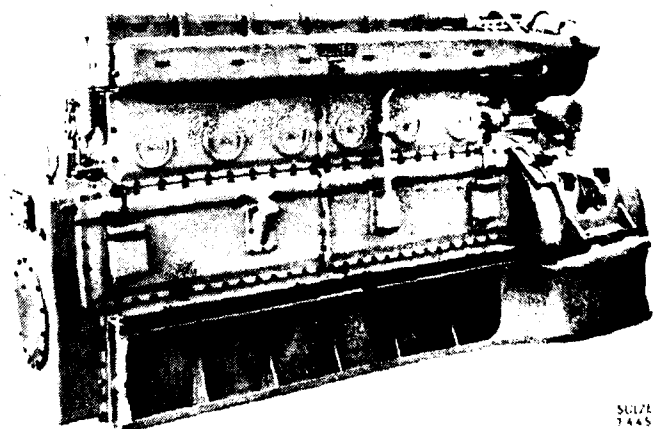
S.L-31 A.F.

Special Diesel Locomotives for Australia

A total of 14 Sulzer-engined diesel-electric locomotives for special operation over the Australian desert is in course of delivery by the Birmingham Railway Carriage & Wagon Co. Ltd. to the Commonwealth Railways of Australia; and in the completeness of modern equipment and in high standard of design they form one of the most important locomotive orders exported from Great Britain.

The first one was tried on the Western Region of British Railways between February 21 and 25. Their power is provided by an oil engine of 955 b. h. p. at 750 r. p. m. supplied by Sulzer Bros. (London) Ltd. and electric transmission and control was built by Crompton Parkinson Ltd.

These locomotives have to operate in temperatures of 110/120 deg. F. and be able to run through sandstorms

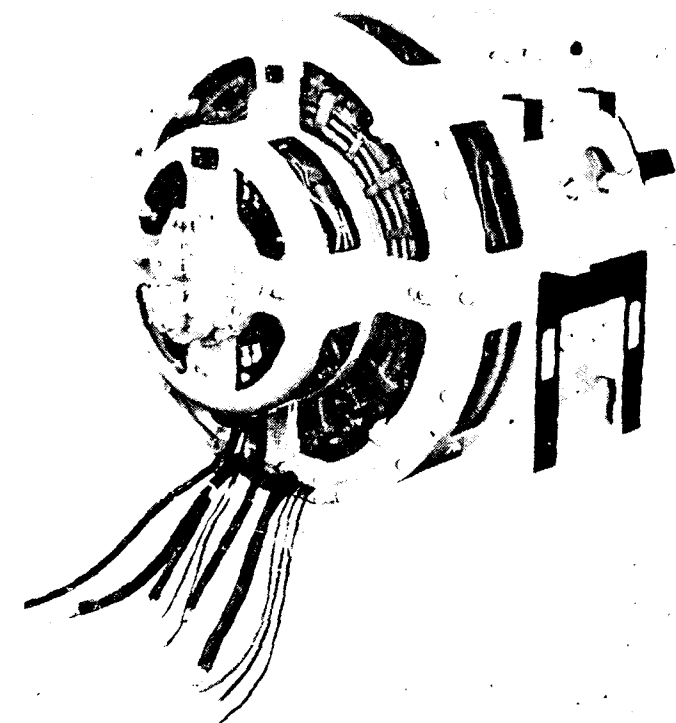


Sulzer 955 b. h. p. engine and Crompton Parkinson main generator, Commonwealth Railways of Australia diesel-electric locomotive.

without damage to equipment. Because of this the whole engine room is pressurised and all the doors, cabiners and roof hatchways are brought up tight against the rubber seals. Air is drawn in by fans and passed through large banks of filters, and only this filtered air is drawn into the engine and generator, and passed along ducts to the force-ventilated traction motors.

An object of the design was to gain great haulage power on an axle load of only 10½ tons, for the Central Australia line, over which these locomotives are to work, is laid only with rails of 40 to 60 lb. a yd. weight. Two three-axle two-motor bogies are used, and the weight of 62½ tons has been achieved without the structural use of light alloys. The tractive effort is enough to haul a 1,000-ton train along the level at slow speeds and 270 tons up the sharply-curved 1 in 60 grades by which the line climbs inland to Quorn from Port Augusta. Top speed is limited strictly to 50 m. p. h. because of the general track conditions over the 770-mile line from Port Augusta to the rail-head at Alice Springs, in the very centre of Australia. The tractive characteristics are 26,800 lb. at starting, and 15,600 lb. at 15 m. p. h. on the continuous rating of the electrical equipment.

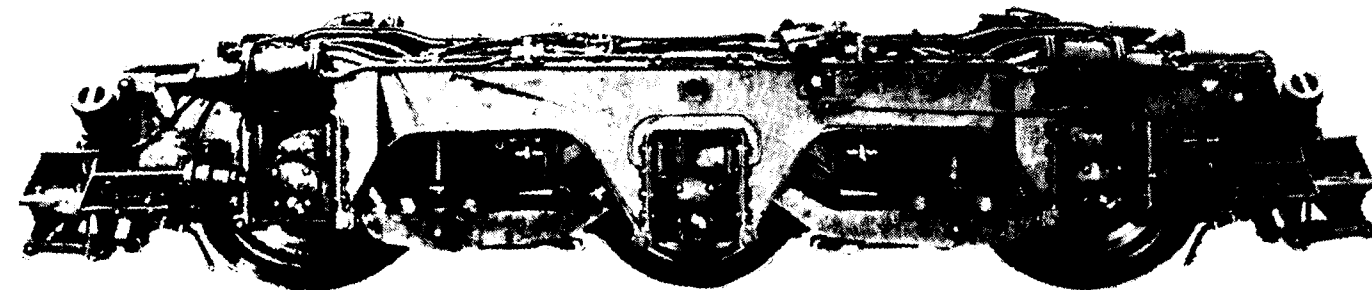
A fully-welded superstructure is riveted to a fully-welded box-section underframe in which main box-section members are used as air ducts to take the ventilating air from the blowers to the electric traction motors. A feature of the whole design is the low



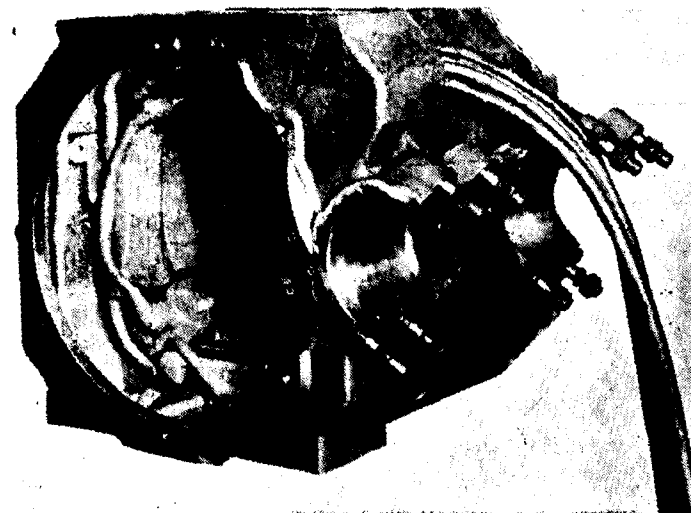
Main d. o. generator with recessed auxiliary generator by Crompton Parkinson for 955 b. h. p. diesel locomotive, Commonwealth Railways of Australia.



955 b.h.p. ALA-ALA 3 ft. 6 in. gauge diesel-electric locomotive of 62½ tons weight and 50 m.p.h. top speed for the Commonwealth Railways of Australia built by the Birmingham Railway Carriage & Wagon Co. Ltd.



Side view of three-axle two-motor swing-bolster 3 ft. 6 in. gauge bogie for 955 b.h.p. diesel locomotive, Commonwealth Railways of Australia.



197 h.p. nose-suspended traction motor of Crompton Parkinson make for 955 b.h.p. diesel locomotive, 3 ft. 6 in. gauge Commonwealth Railways of Australia. There are four motors per locomotive.

height of the underframe, which gives ample space for working on the oil engine cylinder heads without dismantling, and gives a clear walkway 6 ft. 3 in. high right round the power plant.

The frame structures of the swing-bolster equalised bogies are fully welded box sections, designed so that loads are taken centrally and are not offset. There is a wide use of manganese steel on wearing surfaces, and of rubber to control the side play. Shock absorbers also are fitted. The one-piece wheels are pressed on axles supported by Timken roller bearings, and are braked on the Westinghouse compressed air system with Australian standard fittings.

The Sulzer engine is one of a range from 350 to 2,000 b. h. p. built for railway work and nothing else, and has the feature of a fully-welded mild steel and cast steel crankcase framing which embodies also the common underbed for engine and generator. There is special tooth-and-wedge adjustment of the main bearings,

(Continued on page 46)

U. S. Railroads set New Efficiency Records

AMERICAN railways operated at record efficiency in 1953, as a result of their \$10,000 million (Rs. 4,780-crores) postwar modernization programme. Besides adding new freight wagons and passenger cars, the railways have almost completely replaced their steam locomotives with the Diesel type.

Although the railways reached their peak rate of expenditures in 1951, when they spent \$1,474 million (Rs. approximately 704.5 crores) on new plant and equipment, the current capital outlays are at an estimated annual rate of more than \$1,000 million (Rs. 478 crores). Expenditures on equipment are reduced, but outlays on track improvements continue high.

The Association of American Railroads reports that in 1953 the railways handled more tons of freight per train than ever before, and did it faster, and set a record for the average output of transportation per train per hour.

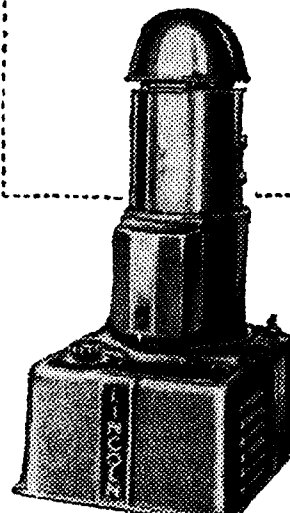
The railways last year moved an average of 23,443 net ton-miles of freight per train-hour. This showed an increase of 878 net ton-miles above 1952, one-third above 1943, and three times as great as 1920.

The average speed of good trains in 1953 was 18.2 miles per hour, the fastest yet. In 1952 the average was 17.6 miles per hour. Last year's average was 18 per cent higher than 10 years ago and 7 per cent higher than in 1920.

(Continued from page 45)

which is combined with caps let into the crankcase to give additional rigidity and eliminate the use of studs in shear. The engine has six 9 in. by 14½ in. cylinders and has a one-hour output at sea-level of 1,035 b. h. p., but to suit the Australian conditions of high temperature humidity it is derated to 955 b. h. p. Its fuel consumption is guaranteed at the low figure of 168 gr. (0.37 lb.) per b. h. p. hr. 20 lb. per h. p.

The 535-kW main and 63-kW auxiliary generators are on the same shaft, and the auxiliary generator is recessed into the main machine to save length. The cast steel rotor common to both machines is of bottle form, giving maximum strength on light weight. The 193 h. p. traction motors are force ventilated from a blower group comprising two blowers and one central electric motor.



LINCOLN

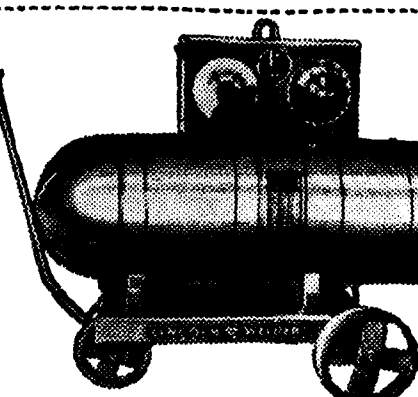
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INTERMITTENT 400 AMPS
(Electrode Size 5/16").



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The Problem of Interlocking the Non-Interlocked Stations on the Indian Railways and its Solution

By L. C. Mohindra, A.M.I.E.E. (Lond.), M.I.R.S.E. (Eng.)

Assistant Chief Design Engineer, Central Standards Office, New Delhi

The article first brings out the importance of providing interlocking at non-interlocked stations in the interest of an increased measure of safety and immensity of the problem in view of a large number of stations at present non-interlocked and the present day costs of providing interlocking to the present standards. The author then offers two signalling and interlocking schemes to meet the gigantic problem in the most economical manner. Each scheme has its own features and utility.

THE NUMBER OF NON-INTERLOCKED STATIONS ON THE INDIAN RAILWAYS AND THE ELEMENT OF INHERENT DANGER INVOLVED THEREAT

THERE are nearly 5,000 stations on the Indian Railways out of which over 2,100 are non-interlocked.

Whereas 10 to 20 per cent of the stations at present non-interlocked are large or are on important sections, the rest are just two line stations with one or two siding connections. At a majority of these stations some signals, however, do exist. These consist of either an outer and a home signal or an outer signal only in each direction. There is no interlocking between the signals and the points at such stations and it is possible for the signals to be taken 'off' regardless of the position of the facing points.

The setting of the points at non-interlocked stations is left to the Pointsmen. Working instructions at such stations, however, do lay down that the Stationmaster and the pointsmen have to exchange line labels for the reception line nominated by the Stationmaster. From the line label the pointsman knows the line on which the Stationmaster desires the train to be received. The exchange of line labels is also supposed to enable the authorities to fix responsibility in the event of an accident. The exchange of line labels, however, does not provide a guarantee that the pointsman will set the points as per Stationmaster's instructions and that he would lock them correctly. This obviously introduces human element and if the staff is not careful, there is a possibility of the reception signals being taken 'off' without the facing points having been set and locked in the correct position. This may result in a train being received at a station on a line which is different from the one required by the Stationmaster and if this happens to be occupied, an accident may result. There is also the possibility of signals being taken 'off'

when siding points may not be correctly lying for the proper running line. This may also result in a mishap. After the accident, it may be possible to fix responsibility and punish the staff, but considerable damage and possibly loss of life may have resulted all the same.

The element of inherent danger present at a non-interlocked station is generally well-known. There have been a number of accidents at non-interlocked stations and the need for providing interlocking at such stations has been felt for many years. When the Railways were first constructed, the traffic was light on certain sections and therefore a stage of non-interlocking may have been acceptable. Most of these sections have been in service for more than thirty or forty years and the traffic has since increased a great deal.

To deal with the increased traffic at these non-interlocked stations with safety, it is desirable that ways and means should be devised to remove the element of danger present there.

The Government Inspectors of Railways have also, from time to time, made recommendations for providing interlocking at non-interlocked stations while dealing with accidents in their annual reports. Extracts from some of the Railway Accident Reports by the Government Inspectors of Railways are given in Appendix A.

From the extracts of the reports of the Government Inspectors of Railways, it would be observed that several accidents have taken place at non-interlocked station, which could reasonably have been expected to be averted if interlocking had been existing at such stations. The Government Inspectors of Railways have also stressed the desirability of interlocking the non-interlocked stations, particularly on important lines in their respective jurisdictions.

It would be of interest to note that the Government Inspectors of Railways, while fully appreciating the difficulties in finding adequate funds, have often stressed

that if funds could not be found for providing complete interlocking according to the Railway standards of signalling and interlocking, some means of partial interlocking should be provided so that there is no possibility of a mistake by which reception signals are taken 'off' for a line different from the one permitted by the Stationmaster and further it should not be possible to alter the position of the points after the reception signals have been taken 'off'.

PRESENT PACE OF PROVIDING NEW INTER-LOCKING INSTALLATION AND THE CAUSE OF SLOW PACE

Although the desirability of providing interlocking at the non-interlocked stations has been urged for a long time, the total number of stations interlocked each year on all the Indian Railways has been less than 50 stations per year. This is due generally to the limited availability of funds. In the 'Five year Programme of Improvement to Railway Signalling' recently approved by the Railway Board, the number of stations proposed to be interlocked on all the six zones during the five year period is 243 only. Since there are over 2,100 stations still non-interlocked, at this rate it will take more than 40 years to interlock all of them. This does not take into account many other stations which may be opened on the new line in the meantime. It will be observed, therefore, that the rate at which interlocking is being provided is rather slow.

The reason why the interlocking of a greater number of stations has not been carried out, as stated earlier, is the shortage of funds and the all-round rise in the cost of material and labour. According to the present day prices, the cost of standard I interlocking at a two line station comes to about Rs. 19,000/- for two aspect signalling and Rs. 30,000/- for multiple aspect signalling. The cost of signalling is correspondingly more for a three line station. The cost of providing standard III interlocking comes to about Rs. 90,000/- per station for two line station and Rs. 1,10,000/- for a three line station.

PRESENT NEED FOR EVOLVING CHEAPER SIGNALLING

Since it is desirable to find ways and means of increasing the safety at the stations at present non-interlocked and the pace of undertaking the interlocking at such stations is slow due to the present day high cost of material and labour, there is a real need today of evolving some simple method of providing interlocking between signals and points so that essentials of safety are complied with.

SIMPLE INTERLOCKING INSTALLED AT NON-INTERLOCKED STATIONS ON THE AMRITSAR-PATHANKOT SECTION OF THE NORTHERN RAILWAY IN 1950-51

In 1949, the need to interlock the Amritsar-Pathankot Section of the Ex. E. P. Railway, where all stations were non-interlocked, became imperative, as it was necessary to provide an increased measure of safety for the movement of armed forces in connection with the hostilities then in Kashmir. Provision of signalling and interlocking to the railways' normal standards required considerable material and time. The problem of meeting the essential requirements of safety in the shortest possible time using the minimum possible material had then to be solved. Accordingly, a simple method of providing interlocking between the points and the signals (existing at the non-interlocked stations) was devised. The general arrangements then devised are shown on a plan at Appendix 'B'. It was termed 'Modified Non-interlocking'. The main features of this method of signalling are as under :—

- (a) The Stationmaster is provided with reception line keys—one for each reception line—viz. 'Stationmaster's main line key' and 'Stationmaster's loop line key' for a two line station. These keys are normally retained in the Stationmaster's custody.
- (b) Hand plunger triple key locks are provided at the facing points. The locks take three keys, viz.
 - i. SM's main line key,
 - ii. SM's loop line key,
 - iii. Signal Key.

The lock is of a special design so arranged that the signal key remains normally locked in it with the points free and the hand plunger lock in the mid-way position. The special feature is that by the application of the SM's main line key or the SM's loop line key, the signal key is released from the lock only after the facing points have been set and locked for the main or the loop line according to the SM's line key applied. Further, the extraction of the signal key locks the hand plunger in a position which holds the facing points locked in that position. The SM's main or the loop key is also then locked in.

- (c) A signal post lock is provided on each of the home signal posts so arranged that the home signal cannot be taken 'off' unless the signal key, normally locked in the hand plunger triple key lock at the facing points, is applied.
- (d) The outer signals are controlled through detachers fitted below the home signals. This permits the outer signal to be taken 'off' only after the home signal is correctly 'off'.
- (e) The siding points are fitted with a single key lock, the points being normally locked for the running line. The siding key may be the same as the SM's line key. This ensures that when the key is used for reception of a train, the siding points on that line are correctly locked for the particular reception line. At stations where the number of sidings is more than two, the siding keys may be separate but are suitably locked with SM's line keys in a key box retained under SM's custody.
- (f) This method of interlocking is quite capable of application with success to stations with more than two reception lines. In fact, it may be applied even to junction stations.
- (g) The cost of providing such interlocking at non-interlocked stations (equipped with home and outer signals generally existing at such stations) is estimated to cost approximately Rs. 2,000/- per station.

Since the signal key is to be applied in the signal post lock before the home and outer signals can be taken 'off' and the signal key can be extracted from the hand plunger key lock only after the facing points have been set and locked for the line according to the key given by the Stationmaster, it is possible for the reception signals to be taken 'off' only after the facing points have been set and locked for the line for which the Stationmaster has issued the Stationmaster's line key.

The proposed method provide essentials of interlocking between the points and the signs as well as full control of the Stationmaster over the signals. Interlocking of the siding point connections with the signals is also included in the signalling scheme. The home signal, however, for reasons of economy, was proposed to be continued as single armed. Since this does not distinguish the reception of a train on the loop line

from a reception on the main line, a driver was expected to observe a speed restriction of 10 miles per hour even when running through on the main line. The system of signalling was, therefore, termed 'Modified non-interlocking', even though it fully assures the basic requirements of safety.

The proposed signalling was accepted and the work was executed by the Railway in 1951-52. This interlocking has been in use since then on the section and has been found effective.

An article detailing the system of interlocking proposed was published in the Indian Railway Technical Bulletin of April 1951. The article contains full details of the proposed method of interlocking with the plans, estimates and the design of lock.

This method of interlocking was also discussed in the signalling and Interlocking Standards Committee held in Feb. 1952. The Committee passed the following Resolution :—

"The proposed method of increasing speed at non-interlocked stations was examined. The Committee consider that where non-interlocked stations have to be interlocked, interlocking in accordance with the standards laid down should be provided and do not recommend the proposed method for general adoption. It is understood that this method was designed at the time when material and funds for interlocking were not available".

While the Chief Signal & Tele-communication Engineers did not find anything specifically wrong with the proposed method of interlocking, they recommended that interlocking in accordance with the standard laid down should be provided.

With due regard to the opinion of Chief Signal and Telecommunication Engineers, the fact remains that the proposed interlocking provides for the following :—

- i. The reception signals cannot be taken 'off' unless relative facing points are correctly set and locked according to the Stationmaster's line key handed over by the Stationmaster to the Pointsman.
- ii. The position of the points cannot be altered after the signals have been taken 'off'.
- iii. The basic interlocking necessary to ensure safety is provided by the provision of a few additional lock at a small cost of nearly Rs. 2,000 only.

Thus the provisions made meet the recommendations made by the Government Inspectors of Railways, year after year, when reporting on accidents. The writer feels, therefore, that there should have been no objection to accepting the proposed austerity standard with a view to providing essentials of safety at such a large number of non-interlocked stations that each railway has, and thus undertake the gigantic problem with the limited funds available. This would no doubt have been consistent with the present economy of our country.

It may be stated that the Signal and Interlocking Standards Committee passed the resolution referred to in para above, they had the benefit of receiving a report on the actual working of the modified non-interlocking on the Amritsar-Pathankot Section which was completed in 1951. In this connection, it may be stated that a reference to this system of signalling appeared in the Railway Gazette of September 1953. An extract of the same is reproduced below.

ECONOMICAL KEY LOCKING IN INDIA

'An increase of traffic on a portion of the former Eastern Punjab Railway now part of the Northern Railway of India—where the single line stations were not interlocked, made it necessary to look for some inexpensive way of getting a reasonable degree of protection and assurance of the correct working of home and outer signals. It was considered essential to give the Stationmaster direct control over them and of course interlocking with the facing points had to be provided. An article in the Quarterly Technical Bulletin by Mr. L. C. Mohindra of the Central Standards Office describes the key interlocking apparatus which has been applied for the purpose and has proved very effective. A hand-worked f. p. plunger is operated by a pointsman, after setting the points in accordance with the main or loop key sent to him by the Stationmaster, and another key, then released, allows the home signal to be pulled off from the station. This in turn allows the pointsman to clear the outer signal from where he stands. Discordance between the two signals is prevented by a detacher on the home post. The cost is only a fifth of what standard I signalling would entail, and one fifteenth of that required for standard III cabin interlocking'.

As regards the experience of the traffic staff actually engaged on the Amritsar-Pathankot Section, enquiries made from the traffic and other officials after the introduction of the proposed interlocking show that the method has found great favour. This would be amply clear from the report of the Government Inspectors of

Railways for the year ending 31-3-52. The relevant extract of the report is reproduced below:—

SIGNALLING AND INTERLOCKING AMRITSAR-PATHANKOT SECTION

'The Stations on this section have been provided with modified type of non-interlocked signalling. Facing points have been fitted with S & F key locks and by handing over particular keys to the pointsmen, the Stationmaster assures himself that the points have been set and locked for a particular route. This is a great improvement on the ordinary non-interlocked working on other Branch lines'.

From the above, it would appear that the system of modified non-interlocking is satisfactory from the operating points of view and thus provides an increased measure of safety at the otherwise non-interlocked stations.

SIMPLE METHOD OF PROVIDING STANDARD I INTERLOCKING

As the Signal & Interlocking Standards Committee, had proposed the provision of interlocking in accordance with the standards laid down, the possibilities of providing interlocking to one of our standards at as low a cost as possible has also been under study since then.

While visiting the Newzealand and Australian Railways in 1951, the writer observed that the interlocking of their roadside stations is quite simple. On those railways, on a great majority of sections they have a single post home signal, with two arms one below the other. The top arm is for the main line, and the one below is for the loop line. These Railways have used this system for many years with great success and there has been no case where this may have caused any confusion to the drivers. This method, in addition, enables the capital expenditure of an installation to be reduced considerably.

The writer considers that this idea is worthy of very useful application on the Indian Railways, as it would enable the existing single armed home signals at non-interlocked stations to be continued without the need of replacement by bracketted home signals. The importance of this would be appreciated all the more when it is known that each two armed bracketted signals costs about Rs. 2,000/- and two such posts are required at each station. When we add to it the freight, carriage, erection and supervision charges, it amounts to nearly Rs. 6,000/- per station.

On the Indian Railways if we accept the placing of a loop home signal below a Main line home signal for two

line stations on branch line sections, it would enable the conversion of non-interlocked stations to Standard I interlocking at a very much reduced cost than if bracketted signals were to be provided.

It will be observed that if this system of signalling was accepted for an entire branch line section, the question of confusion with a possible outer and Warner combination would not arise. This is merely a question of changing the outlook which would yield us substantial returns. For further clarity the loop home signal arm could be fitted 10' to 12' below the main home signal arm and the size of the arm can be reduced so that even under the most adverse circumstances there is no possibility of confusion with any other combination.

POSSIBILITY OF REDUCTION IN THE RECURRING EXPENDITURE

Another point of interest learnt from the Newzealand and Australian Railways is that at roadside stations they have only one person in charge of the station in each shift without any pointsman to help him. This is achieved by keeping the facing points set and locked for the main line and their interlocking keys normally retained in the Stationmaster's custody at the station. The signal arrangements are such that when a train is to be received on the main line, the relevant signals can be taken 'off' by simply applying the key concerned in the controlling lever of the signal at the station. As regards the reception on the loop line, this is arranged by the Stationmaster by application of the key at the points. The general practice on those railways is to receive trains on the main line unless trains have to cross, in which case the Stationmaster himself has to proceed to the facing points and set them as required. With this method they require no pointsman. The conditions prevailing on the Newzealand and Australian Railways are, however, different and cannot be applied wholesale on the Indian Railways, but can suit the prevailing conditions with certain modifications.

On the Indian Railways, we have at present two pointsmen in each shift of duty, one for each end of the yard. Both the pointsmen are required to proceed for the reception of a train—one at the facing end and the other at the trailing end. To apply this principle of keeping the points normally locked for the Main line, a signalling and interlocking scheme has been devised with the following main features:—

- (i) The main and the loop home signal placed on the same post for two line stations.
- (ii) The facing points have been kept normally set and locked for the main line and their keys

retained in the personal custody of Stationmaster on duty at the station. The main line home signal levers are operated from the station and are released by the application of the facing point lock key (Main line key), normally at the station.

According to this procedure no pointsman need proceed to the facing points when a train has to be received on the main line.

- (iii) When a train has to be received on the loop line, it is necessary for the main line key normally at the station to be sent to the facing points. The pointsman then unlocks the facing points, sets them for the loop and releases loop home signal key. This key is applied in the loop home signal post lock fitted on the home signal post. This releases the loop home signal arm and enables the Stationmaster to pull the loop home signal lever and take 'off' the loop home signal. The pulling of the loop home signal lever also releases the outer signal lever at the station lever frame.
- (iv) The procedure of crossing trains at such stations would consist of the Stationmaster directing the pointsman to proceed with the main line key to the facing points in the direction from which a train has to be received on the loop line. The pointsman would have instructions to set and unlock the points, lock them for the loop line and arrange for the signal lock on the loop home arm to be freed. This having been done, the Station Master would take 'off' reception signals for the first of the two approaching trains on the line allotted without any further action by the pointsman. After a train on the loop line has been received, the pointsman would set and lock the points for the main line, ready for the other train to leave. He would then proceed to the trailing points and arrange despatch of the train on the loop line.

According to the above procedure the trailing points would be set in favour of approaching train and this would conform to the recent directive, according to which when trains have to cross, before signals for the first train are taken 'off' the points at the far end should be against this train and for the second train.

A plan showing the proposed method of interlocking, incorporating the feature of loop home signal being fitted below the main home signal, and the points normally

set and locked for the main line is at Appendix 'C'. The cost of conversion from non-interlocked to Standard I interlocking according to this method would be about Rs. 7000/- only per station. The details are given in the estimate at Appendix 'D'.

At stations where platforms are rail-level, it may be possible to adopt the procedure of normally receiving trains on the main line and thereby effecting saving in the recurring operating expenditure. This saving will amount to Rs. *3505-8-0 per annum where three pointsmen are saved and Rs. 2,200/- per annum where two pointsmen are saved. The introduction of signalling would thus be a sort of gold mine.

Considering the desirability of evolving a cheaper method of interlocking, consideration of the above-mentioned scheme was included in the agenda of the 27th meeting of the Signalling and Interlocking Standards Committee held in Feb. 1954. Extract of the resolution by the Committee is as under :—

- (i) "The Committee consider that the proposed method of signalling would be suitable for branch line sections and recommend that this may be tried.
- (ii) As regards the provision of loop line home signal below the main line home signal, the same may be accepted for branch lines where the complete section is equipped with Standard I interlocking without any distant/warner signal.

* Levermen.	Scale	Rs.	35-1-50
Average pay Max+Min	=	Rs.	42-8-0
Dearness allowance	=	Rs.	45-0-0
Leave Salary Pay+DA 20	=	Rs.	4-6-0
Gratuity = Pay+LS 24	=	Rs.	1-15-0
P. I. Fund	=	Rs.	3-9-0
Total expenditure for 1 man per month.	=	Rs.	97-6-0
Total expenditure for 1 man per annum.	=	Rs.	1,168-8-0
Total expenditure for 3 men per annum.	=	Rs.	3,505-8-0
Total expenditure for 2 men per annum.	=	Rs.	2,337-0-0

The following exception to Rule 1, Section D of Chapter VIII of the revised draft rules for the opening of a railway may be adopted—

'Exception (vi)—On branch line sections at two line stations where there are no warner signals the loop home signal arm may be placed on the same post and below the main home signal arm'.

From the above it would be observed that the Committee have accepted the method of proposed interlocking.

The question of providing rudimentary interlocking at non-interlocked stations has been raised from time to time. It is considered that provision of Standard I interlocking at stations, where saving in operating expenditure is possible, should be better than modified non-interlocking. But at others where saving in staff is not possible and provision of interlocking to proper standards cannot be taken in hand due to limited availability of funds, modified non-interlocking is obviously the answer.

Both the schemes have already been discussed in the Signal & Interlocking Standards Committee meetings and from signalling and safety point of view have been accepted. The choice can now be made by the Transportation Department in consultation with the Signal Engineers based on the requirement of each section.

CONCLUSIONS

1. To ensure increased measure of safety to the travelling public, it is desirable that non-interlocked stations should be interlocked. The number of non-interlocked stations on the Indian Railways is nearly 2,000. The cost of signalling a two-line station is approximately Rs. 20,000/- for Standard I and Rs. 90,000/- for Standard III and correspondingly more for a three line station. The cost of conversion of a non-interlocked station to Standard I with bracketted home signals is approximately Rs. 12,000/-. Due to the limited availability of funds and the enormous cost involved, the problem is gigantic and evolution of a more economical system of interlocking providing essentials of safety is an urgent necessity.
2. The solution of the above problem lies in providing either of the following methods of interlocking as a first step :—

- (i) Modified non-interlocking (details in para above)
 - (ii) Standard I interlocking, (details in paras above).
3. (a) The conversion of a non-interlocked station to "modified non-interlocked", which costs Rs. 2,000/- per station only, is obviously most economical, and should be provided where saving in operating staff is not feasible—See para 3(b) (i).
 - (b) Standard I interlocking as per design described in paras 13 and 14 costs Rs. 7,000/- for interlocking a 2 line non-interlocked station, and is worthy of adoption in preference to modified non-interlocking in the following circumstances :—
 - (i) At stations where saving can be effected in the number of pointsmen by keeping the points normally set and locked for the main line. This is feasible where traffic is not heavy, train crossings are not frequent and platforms are low.
 - (ii) Where traffic on the section demands Standard I interlocking.

The circumstance detailed in (i) above obtain at a large number of branch line stations. By adopting this system, saving in the recurring operation expenditure to the tune of Rs. 2,200/- can be effected at stations where two pointsmen can be saved and Rs. 3,500/- at stations where three pointsmen can be saved.

This saving would yield 30% to 50% return on the capital expenditure, in addition to other advantages of added safety and higher speeds through main line.

4. Both the proposed system of interlocking have been discussed in the Signalling and Interlocking Standards Committee Meetings and from the Signalling and safety points of view have been accepted. The gigantic problem of providing increased measure of safety at the non-interlocked stations can now be solved most economically by adopting either of the two proposed systems.

APPENDIX 'A'

Extract from some of the 'Railway Accident Reports by the Government Inspector of Railways' are reproduced below.

- (i) Extract from the report for the half year ending 31st March 1929 in connection with an accident at Bhatni Station Yard on the Ex-Bengal and North Western.
"Recommendations.

- (25) It is strongly urged that some system of interlocking points with signals should be introduced at an early date on the main line at least of the Bengal and North Western Railway. The traffic has long warranted it and the present programme of a few crossing stations and one junction a year is very inadequate. A much more rapid programme is necessary".

- (ii) Extract from the report for the half year ending 30th September 1935 in connection with an accident to 49 UP Grand Trunk Express at Gorandongri station on Itarsi-Nagpur Section on the Ex-G.I.P. Railway.

"Remarks.

I consider that in the interests of safety, the present non-interlocked stations on the Wardha-Balharshah and Itarsi-Nagpur Sections of the G. I. P. Railway should be wholly or at least partially interlocked. If funds are not available for the full locking of all stations according to G. I. P. Railway Standards, then at least one of the cheapest forms of the simplest key locking should be provided at least at the stations where passenger express trains run through daily".

- (iii) Extract from the report for the half year ending 30th September 1936 in connection with collision between No. 360 Down Mixed train and an Up Empty Mela Special at Kalyat on the Ex-North Western Railway.

"21. It must be admitted that though improbable, it is quite possible and it would undoubtedly be much better if the working were so arranged that once everything is set no alteration is possible without the Station Master's knowledge. To effect this, the only method is to make the Station Master himself go to the facing points and take possession of the key of the pad-lock after the points are locked. This cannot

be done without increasing staff as the Station Master on duty has also to attend to booking of luggage and passengers' tickets at these small stations.

22. An alternative is to fit all facing points with double facing points locks. The Pointsman after setting and locking the points returns one key to the Station Master and with this key in his possession the Station Master knows which line the points are set for, and he also knows that the points are locked and cannot be moved as long as he keeps the key".

- (iv) Extract from the report for the half year ending 30th September 1937 in connection with a collision between 159 UP passenger and 170 Down passenger train at Santohpur on Ex-Eastern Bengal Railway.

25. "Remarks and Recommendations—This accident is one which would not have occurred, had the station been interlocked. I recommend that in the interest of safety, the present non-interlocked stations on busy suburban sections of the Eastern Bengal Railway should be interlocked or if funds do not permit, at least partially interlocked.

26. It is desirable that at non-interlocked stations, Home Signals should be detected through the respective facing points so that it may not be possible for pointsmen to alter the setting of the points after the Home signals have been lowered".

- (v) Extract from the report for the half year ending 1946 dealing with an accident at Golandu Ghewar Bazar (B. A. Rly.)

'The cause of this accident was that the down facing points were incorrectly set for the loop line'.

- (vi) Extract from the report for the year ending 31st March, 1947 in connection with an accident at Bhatni on the Ex-O. T. Railway. :

'Recommendations were made ... and that important non-interlocked stations on the main line should be interlocked'.

- (vii) Extract from the report for the year ending 31st March, 1949 dealing with an accident at Kurukshetra (non-interlocked) on the Ex-E. P. Railway and Nawadah (non-interlocked) and Bhagalpur (non-interlocked) on the Ex-E. I. Railway as below.

- "(vii) —Kurukshetra (E. P. Railway)—The accident was due to points No. 2 of Kurukshetra station (non-interlocked) having been wrongly set for the main siding on which the rake of an Empty Coaching Special had been stabled, with the result that 142 Down while leaving the station.....collided with the empty rake".

Recommendations were made to interlock Kurukshetra Station Yard.

"Nawadah (E. I. Railway)—Before the points were correctly set, signals were lowered and the latter train came on to the main line and collided head on with 282 down".

'Bhagalpur (E. I. Railway)—The accident was caused due to No. 23 Up passenger having been wrongly admitted to line No. 3 on which wagons were stabled. To avoid recurrence it was recommended that Bhagalpur station should be interlocked as soon as possible'.

- (viii) Extract from the report for the year ending 31st March 1950 in connection with an accident at Bataspur (non-interlocked) E. I. Railway --

'The accident was caused by the incorrect setting of the down facing points at the station'.

COST OF CONVERSION OF NON-INTERLOCKED STATIONS TO STANDARD I INTERLOCKING

No.	Description	Quantity		Cost		Total
			Rate	Unit		
1	Masonry for 6 lever frame	1	1,000	lot		1,000
2	Lever frame 6 levers	1	250	each		1,500
3	Lever locks single for loop lines	2	50	do.		100
4	Lever lock double for main lines	2	75	do.		150
5	S. M's key box	1	15	each		15
6	Gauge tie plates complete	2	20	do.		40
7	M. S. Plates for locks etc.	L. S.				20
8	H. P. lock triple, taking main keys and loop keys and signal keys complete with stretcher blades	2	250	do.		500
9	Switch extension pieces for detectors	4	10	do.		40
10	Solid joints 1½"	8	8	do.		64
11	Detector 2 way	2	110	do.		220
12	C. I. foundations	2	20	do.		40
13	Cement concrete	L. S.				40
14	Additional fittings for one arm below main home	2	250			500
15	Signal post lock single taking loop home key	2	100			200
16	Cabin wire adjusters	4	50			200
17	Wire adjusting screws	2	15			30
18	Cranks for signals	2	12			24
19	Vertical wheel double	3	12			36
20	Draft rope wheel	4	10			40
21	Horizontal wheels	2	12			24
22	Wire ropes	100 ft.	-/10/-			62
23	G. I. wire 7 strand	4 cwts.	45			180
24	Pulley stakes	75	3			225
25	Shackles, Thimbles, Sleeves Spitpins etc.	L. S.				50
26	Siding lock double	1	200			200
27	Siding lock single	1	100			100
28	Warning Boards	2	75			150
29	Speed Boards	2	50			100
30	Miscellaneous items	L. S.				50
31	Tools and Plant	L. S.				50
32	Labour and supervision	L. S.				500
						6450
33	Freight charges on stores. Rs. 5950/-	6		%		357
34	Carriage charges	L. S.				50
						6857
35	contingencies	5%				343
						7200
36	Less cost of 2 levers, and 2 wire connections to be released					200
						7000

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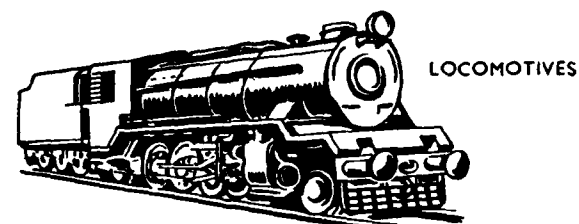
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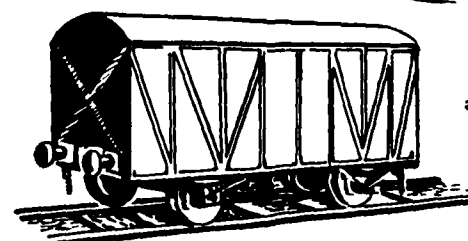
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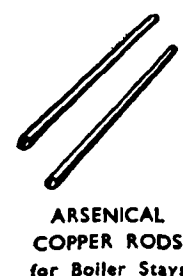
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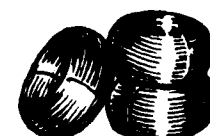
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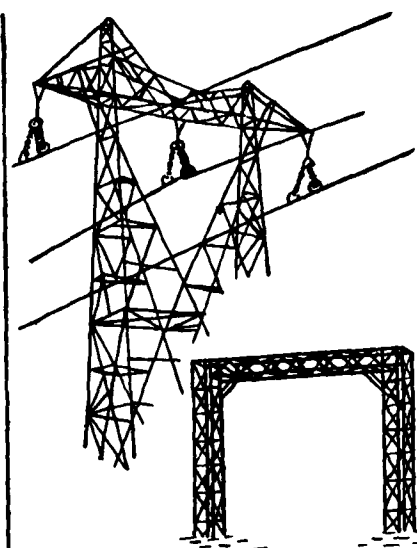


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The Coach bodies are being built with the accommodation and floor plan arrangements as shown in Fig. 1. It will be seen that arrangements are in the nature of having two passenger compartments, two luggage vans; and a guards compartment at one end. The two passenger compartments have one swing door between them to maintain inter-communication. The seating arrangement in the passenger compartments is of transverse type with fixed upper berths supported by Stanchion racks and fixed on the roof by mild steel straps of 2" x 1/4" section. In between the upper berth and the roof is located a light luggage rack as will be seen from Fig. 2.

The underframes on which these coaches are being built, are of IRS design of the built up type composed of high tensile steel sections fitted with top operated hand brake. The Coach body structure is of strong timbered construction. The bodies have straight sides and are 9'-11.3/16" over panels. The body exterior is of 3/32" thick mild Steel panel plates. For roof panning, masonite tempered hard board of 1/4" thick has been used. The interior panning of the guard and passenger compartments has been made with holoplast sheets or masonite tempered hard boards, depending on their availability, using wooden casing boards for the luggage vans.

The floor of the guard and passenger compartments is made up of G. I. P. pattern wooden floor boards on which is laid the "Elephant Brand Red flooring Composition" to a thickness of 1/2" at the centre and 3/4" on the sides. The luggage compartment floor is finished with wooden battens fixed on floor boards. The roof carlines are of 1 1/4" x 1/2" mild steel flat section to take the roofing boards which, in turn, are covered by a layer of "Ruberoid" roofing two ply felt. This is made weather-proof by the application of hot roofing compound.

The seats in the passenger compartments are 23" wide with a minimum hip width of 19 1/2" per passenger. They are arranged to provide a minimum knee room of 21". Resting on cast iron legs these are located at a height of 16" above the floor level. The seats and backs are designed to offer a comfortable sitting posture. They are made up of timber frame with match boards laid on the seat frame and secured by means of nails, and backs boarded up with masonite hard boards fixed on the frame by screws. Dust-harboring crevices have thus been avoided so as to discourage vermin infestation.

The luggage compartments have sliding doors and are equipped with luggage racks, shelves and bullion chest. The guard's compartment has two dog boxes located transversely. It is provided with a seat and table, light

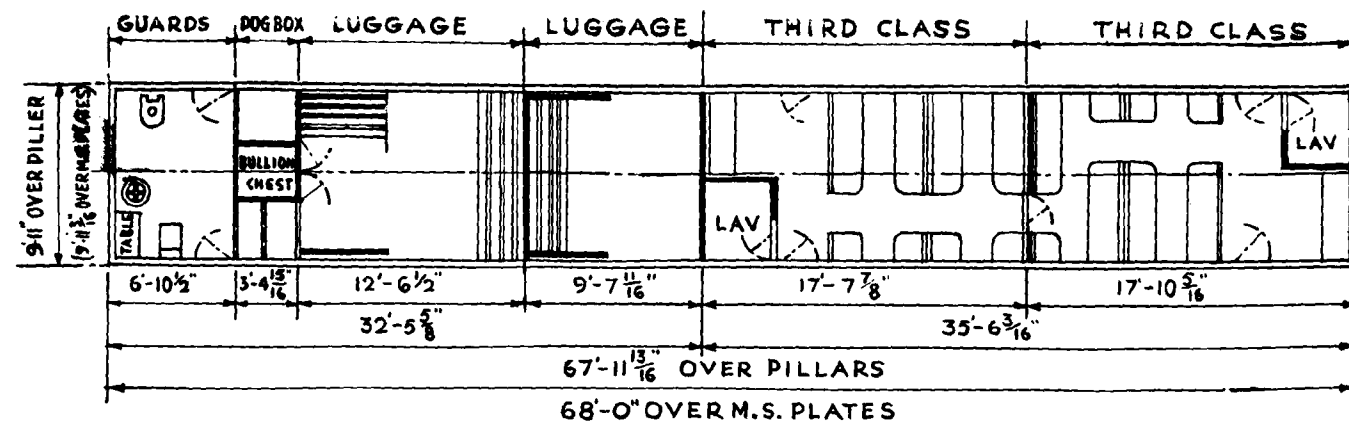


FIGURE 1

luggage rack, hand lamp bracket and pigeon hole besides a commode, mirror and wash basin.

As different types of coaches are being produced simultaneously, the production techniques are those which would be expected in a Factory working on the "batch" type of order.

For the economical production, a number of components is manufactured on a sub-assembly mass production basis in the section created for the purpose. These sub-assemblies converge on the main shop where they are finally assembled to form the coach body.

The programme of work is carried out in the order mentioned below. To work to a schedule, rough time estimates, as indicated against the stages of work, have been calculated. It may be mentioned that these timings are not to be taken as the ideal.

Programme of work	Man hours involved
I. Timber marking	356
II. Sub-assembly	1828
III. Cabinet & Bench Section	1514
IV. Floor framing & laying of floor boards	770
V. Roof and tank fittings including other sundry fitments for body guard and luggage compartments	1500
VI. Assembly	6000
VII. Miscellaneous	532
VIII. Decoliting	288
IX. Pipe Work	472
X. Fitting of hand brake fittings	424
XI. Painting and final finish	1600
Total Man hours ..	15,284

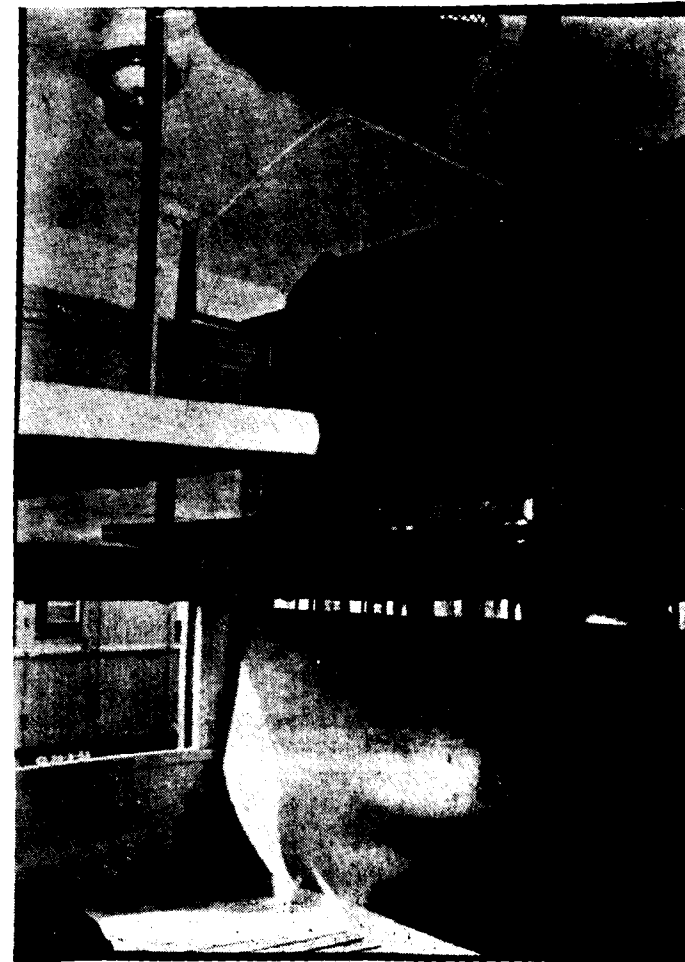


Fig. 2 Interior view of the Compartment.

TIMBER MARKINGS

To ensure that correct sizes of timber scantlings as required, are supplied by the Sawmill, a gang from the construction shop is posted to work for marking the scantlings. Timbers required for bottom sides, end

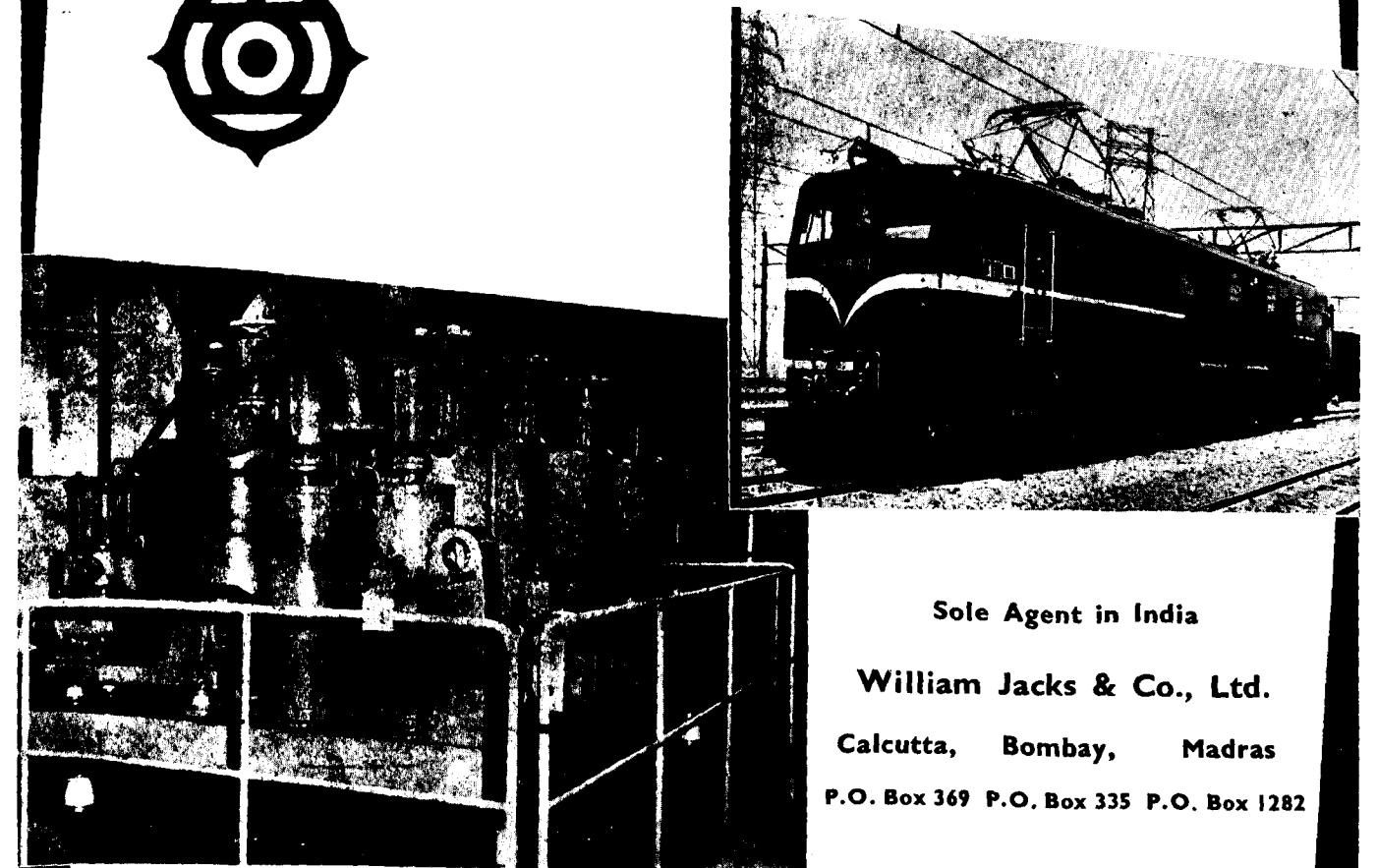
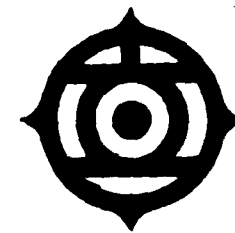
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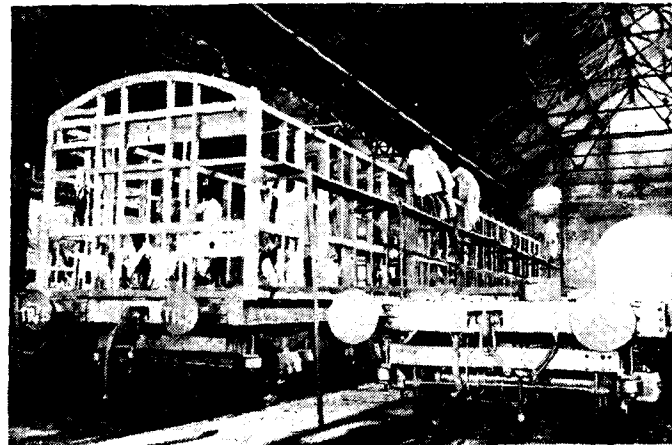


Fig. 3 Skeleton Body of the Coach under construction.

bearers, cross bearers, longitudinals, pillars, waist rails, window head rails, cant rails, partition frames, seats, upper bunks, doors, foot-boards, latrine ceiling frame, window frames, dog box partition and frames, sliding

doors etc. are all marked by these men for the sawmill to cut them to the required sizes.

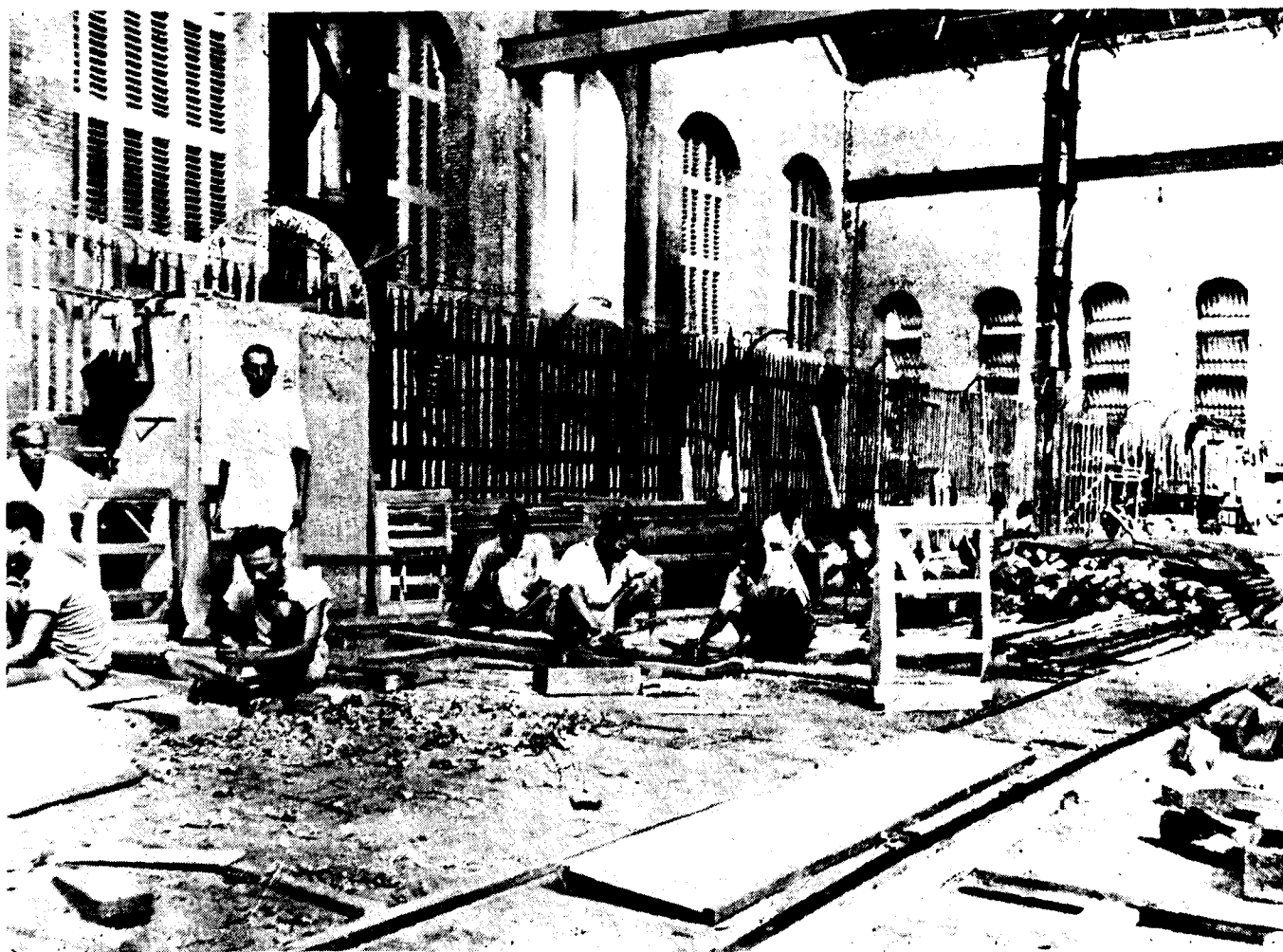
SUB-ASSEMBLY

The following items are manufactured in the Sub-Assembly section :—

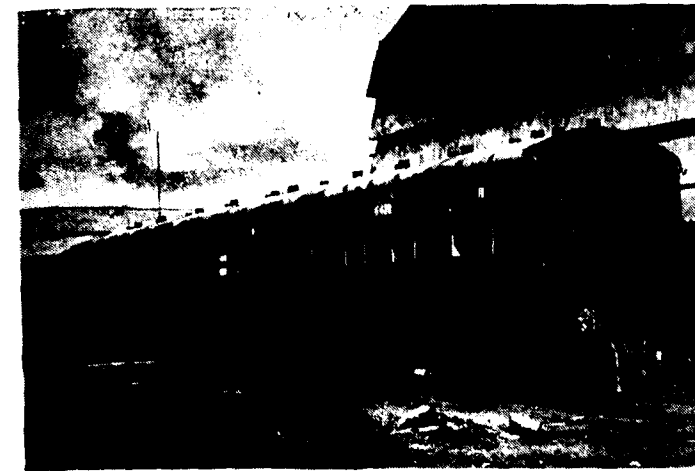
- (i) Seat partitions and seat flaps
- (ii) Upper bunks and their partitions
- (iii) Sliding doors and pockets for sliding doors
- (iv) Body side, partition and latrine doors
- (v) Latrine ceiling frame

CABINET AND BENCH SECTION

This section deals with the manufacture of (a) window frames, (b) luggage racks, (c) Shelves, (d) Mirror frames, (e) dog box sliding doors, (f) dog box ventilation side frames, (g) lotah brackets and (h) battery boxes.



General view of sub-assembly section.



A complete Coach (exterior view)

FLOOR FRAMING AND LAYING OF FLOOR BOARDS

In commencing to build the carriage body the bottom sides as received from the Sawmill are the first timbers laid down. The bottom sides are mortised for the end bars and at correct intervals for the floor and intermediate bearers, as well as for all the pillars. The bearers having been planed, rebated and tenoned, are then fitted into place and well cramped up. To make the framing stronger, the internal angles formed by the connection are further secured by means of mild steel knees of size 6"x6"x1 1/2"x5/8" firmly bolted on. Jointing paste is used in all joints and under all metal work. After this framing is completed, G. I. P. type floor boards are laid on and secured by means of 2 1/2" No. 14 wood screws.

ROOF AND TANK FITTINGS INCLUDING OTHER SUNDRY FITMENTS FOR BODY, GUARD AND LUGGAGE COMPARTMENTS

As it is essential to get the supply of roof carlines and tank suspension fittings before the work of body framing is taken in hand, the smithy and machine shops are entrusted with the responsibility of fabricating and supplying these fittings to body construction shop in time. Other body fittings including those required for the luggage compartments are also manufactured by these shops and supplied to the Construction Shop.

ASSEMBLY

From this operation and onwards the body gradually gets into shape. The body framing along with the partition frame is built by fixing end rails, pillars, waist rails, window head rails, arch rails, cant rails, tank suspension fittings etc. in their respective positions as required and finally completed by fitting roof carlines to

the cant rails. Fig. 3 shows a coach undergoing this operation.

After the carlines are fitted, the roof packings and roof boards are fixed and the timber portion of the work on the roof is completed having the ceiling boarded up with masonite tempered hard board sheets of 1/8" thick.

The men doing this work, then divide themselves into 4 groups to take over the following jobs :—

- Group—1. Fixing and finishing of body side doors
- Group—2. Inside panelling and furnishing
- Group—3. Coach exterior work comprising the panel plating, fixing of mouldings, water strips and hand holds
- Group—4. Work connected with latrine finishing

MISCELLANEOUS

The work done is in the nature of fitting alarm communication apparatus foot boards, completing other small details and finally attending to petty defects,

DECOLITING

The millwright shop then takes over the coach from the Construction Shop to treat the floor with the "Decolite"—a composition which is applied in a plastic condition and given a trowel finish.

PIPE WORK

The operations involved are :—

- (i) Connecting the pipe connections in the lavatory, Guard's Compartment and inside the dog boxes from the roof tanks
- (ii) Fitting Gravity lotah filler cocks
- (iii) Fitting wash basins and push cocks in the lavatories and Guard's Compartment
- (iv) Manufacturing and fitting water troughs in the dog boxes

FITTING OF HAND BRAKE FITTINGS

This is done by the underframe shop, the components are supplied loose by the Firm supplying the Underframe and they are fitted in these shops.

PAINTING AND FINAL FINISH

The stages of work that the coach has to undergo are :—

- (i) Priming
- (ii) Exterior cleaning and painting
- (iii) Interior painting
- (iv) Underframe painting
- (v) Lettering
- (vi) Final touch up and trimming

The finish of the exterior is carried out in synthetic paint enamel gulf red to B. S. C. 73 with ends and roof painted black.

The colour scheme adopted conforms to the Indian Railway standard practice and is as follows:—

- (i) Exterior upto cant rail—Gulf red to B. S. C. 73
- (ii) Ends— Black
- (iii) Roof— Unpainted
- (iv) Lettering :—
 - (a) Body— Imitation Gold to B. S. C. 56
 - (b) Underframe— White
- (v) Inside— Dark brown paint to B. S. C. 12 to match the holoplast where used, otherwise seat and upper bunks grass green to B. S. C. 18, walls sea green to B. S. C. 17 and window frames Dark Brown paint to B. S. C. 12
- (vi) Ceiling— White matt finish
- (vii) Lavatory fittings and pipe connections Aluminium
- (viii) Underframe :—
 - (a) Under gear— Black Bitumen
 - (b) Solebar — Black special

To speed up work, the train lighting section of the Electrical Department work side by side so that their portion of work can run concurrently along with the work of the Mechanical Department.

Important features and principal dimensions of the Coach are given below:—

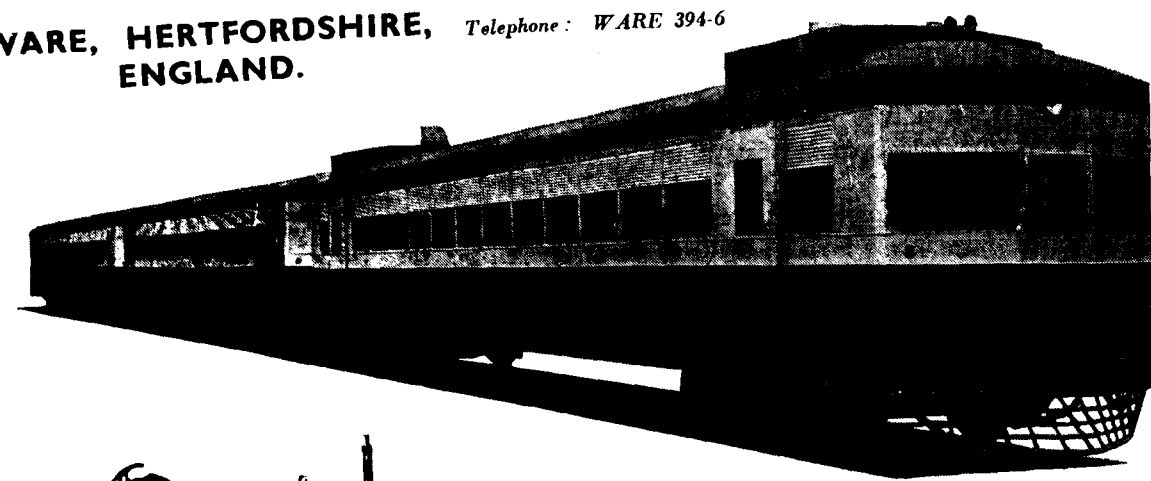
1. Length of body over panels	68'-0"
2. Width of body over panels	9'-11.3/16"
3. Floor area (inside)	617.55 Sq. ft.
4. No. of Compartments	2 excluding 2 lugg: and 1 brake
5. No. of Lavatories	2
6. Area of Lavatory	14.88 Sq. ft.
7. Passengers per compartment	19
8. Floor area per passenger	8.51 Sq. ft.
9. Centre of journals	7'-4"
10. Size of journal	10" x 5"
11. Dia. of wheels en tread	3'-7"
12. Bogie wheel base	10'-0"
13. Centres of bogies	48'-0"
14. Min. lighting per sq. ft. at 33" above floor level	1.5 foot candles
15. Total No. of fans provided	4 excluding 1 in the Guard's compartment
16. Total No. of Mirrors.	2 do. do.
17. Weight of underframe	22.28 tons
18. Weight of body	16.15 tons
19. Tare of equipped coach	Tons Cwts. 41 1 Qrs. Lbs. 0 0

ACKNOWLEDGEMENT

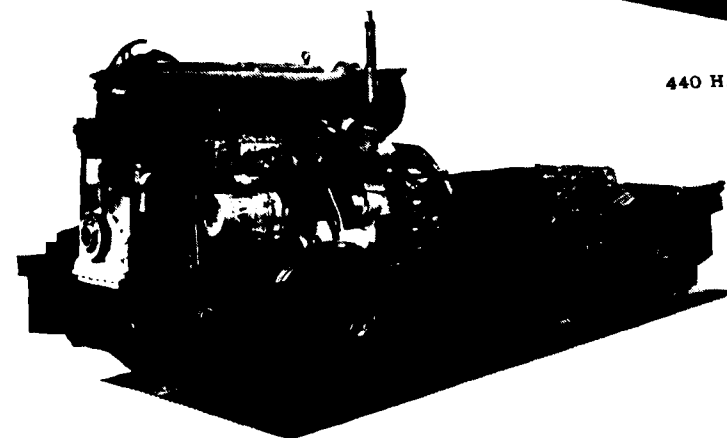
The author is indebted to Mr. R. Subbiah, Dy. Chief Mechanical Engineer, Eastern Railway Workshops, Kanchrapara for his interest and encouragement in producing this paper and to Mr. K. Ramachandran, Chief Mechanical Engineer, of Eastern Railway for his permission to publish it and reproduce the photographs received from the Public Relations Officer, Calcutta Railways.

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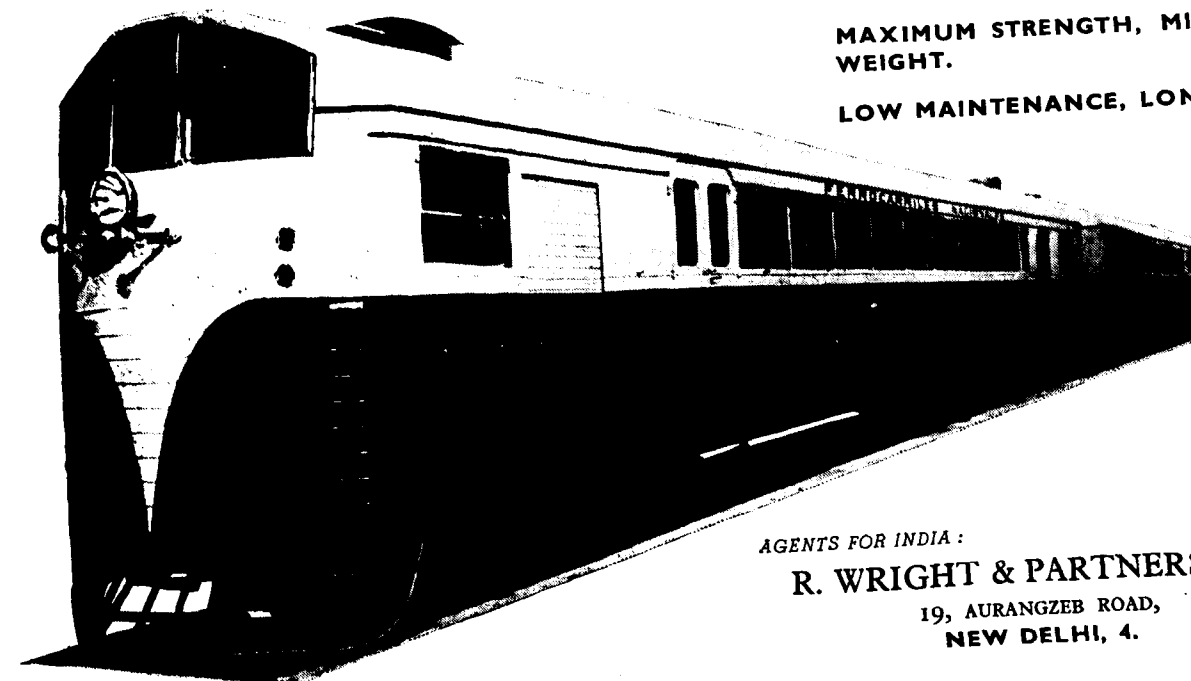
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MR. S. C. B. MAZUMDER, CHIEF ELECTRICAL
ENGINEER, GORAKHPUR

MR. S. C. B. Mazumder B. Sc. (Glasgow) (Elec & Mech.), C. P. E. (Glas.), M. I. E. E. (Lond), till recently Deputy Chief Electrical Engineer, Southern Railway, has been promoted as Chief Electrical Engineer, North Eastern Railway, with Headquarters at Gorakhpur.

Joining the former Madras & Southern Maharatta Railway Unit as an Assistant Electrical Engineer he served at Madras and Hubli till June 1941 when he was allowed to accept a King's Commission and his services were lent to the Contracts Directorate in the Indian Ordnance Army Corps. This Department having been amalgamated with the Director-General, Munition Production, Mr. Mazumder held charges as Deputy Director, Planning and Purchase for Railway materials till March 1946 when he was recalled by the Railway. He was then posted as District Electrical Engineer, Perambur, till May, 1950 when he was transferred to the former G. I. P. Railway, Bombay.

Subsequently he was promoted and transferred as Deputy Chief Electrical Engineer, Southern Railway in May, 1952 and held this office till his transfer to the North Eastern Railway as Chief Electrical Engineer, in the last week of May this year.

Fortynine-year-old Shri S. C. B. Mazumder, was born in Bengal and had his early education in Calcutta. He left India for U. K. for higher studies in July 1921. He graduated in Electrical and Mechanical Engineering from the University of Glasgow and after necessary training in various Workshops, viz., Messrs. William Beardmore, Dalmuir, Walter McGee & Sons, Paisley and Harland Engineering Company (British Electric Plant Company, Alloa), was one of the very few Indians in those early days in U. K. who held executive appointments in that country. He served with Messrs. Merry & Cunningham Co., Blantyre, Harland Engineering Co. (British Electric Plant Co.), Alloa, and finally with Glasgow Corporation Tramways Department, Glasgow.

INDUSTRIAL ADVISER

Dr. D. R. Malhotra, scientist and former Chief Chemist and Metallurgist of the Western Railway, took charge as Industrial Adviser to the Government of India.

He will be attached to the Planning Commission and the Ministry of Rehabilitation.



Mr. S. C. B. Mazumder.

The extensive experience Mr. Mazumder had in the Glasgow Corporation particularly in the Power House for generation of electric supply, in one of the world's biggest Tramways system, was appreciated by the then Chairman of the Glasgow Corporation, Sir James Bailie Higgins in a letter issued by him, which, inter alia, reads as follows :-

"... But for a natural desire to be back amongst his own people this youngman would have not difficulty in obtaining a very high position in this country".

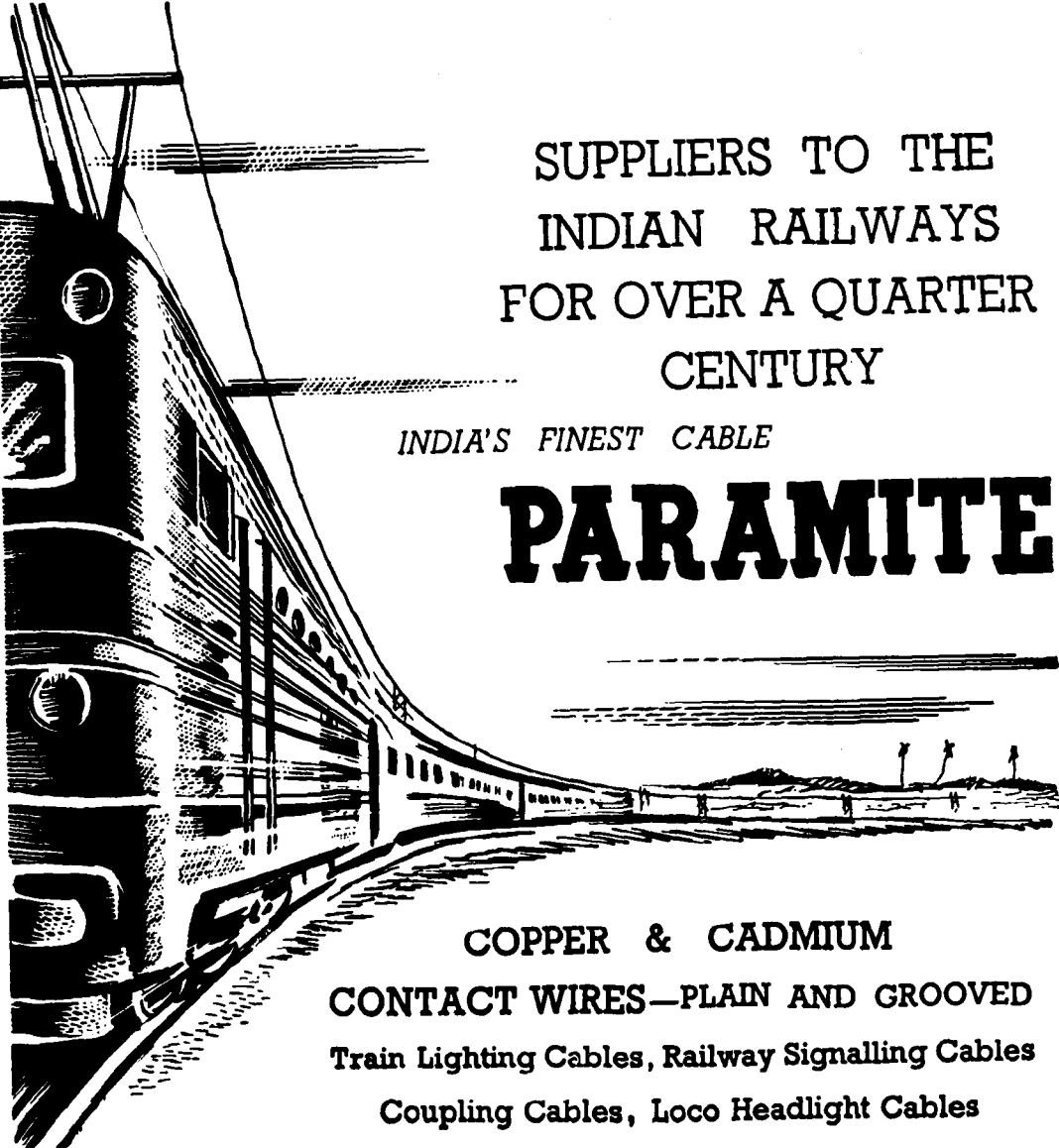
On his return to India Mr. Mazumder was appointed for some in the beginning of 1932 as Electrical & Mechanical Engineer with Messrs. Shaw Wallace & Co., in Central India till December 1937 when he decided to join the Railway Engineering Service.

As Deputy Chief Electrical Engineer of the present Southern Railway Unit Mr. Mazumder has done commendable work connected with the preparation of estimates, plans etc. for electrification of new tracks over that system and have no doubt that he will acquit himself creditably in his new assignment. We take this opportunity of wishing him further success in his new job.

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lower one the bogie of this coach together with the
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