THE INDIAN RAILWAY ENGINEER

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INDEX TO ADVERTISERS

ANNOUNCEMENT

We have pleasure in informing our readers that a Special Number entitled "CARRIAGE & WAGON SHOPS SUPPLEMENT" is being issued along with our April 1958 quarter's edition. This will be very interesting and will carry valuable technical articles, write-ups etc., from well-known authors and international manufacturers of rolling stock and ancillary equipments for the Railways.

TECHNICAL EDITOR.

TRAINING FOR DIESEL ENGINE TRACTION ON RAILWAYS

IN 1952 it may be said that America switched over to Diesel Traction for her Railways because in that year for the first time in U. S. A history, the number of Diesel Locomotives built in America exceeded the number of Steam Locomotives. But the dieselisation of Railway Motive Power was not such plain sailing as would be expected from a country like America.

There was nothing wrong with the diesel locomotives built to replace the steam ones. The design was good and the tractive power available was more than sufficient to meet the most arduous conditions of Railway traction due to heavier loads, steep gradients and higher speeds.

The failure which occurred and which set back the time clock of Railway diesel traction in America by 2 years was due to a shortage of trained personnel to maintain these engines in good condition.

The diesel engine unlike the old steam horse is a tricky piece of mechanism and will not take the same rough usage as a steam locomotive and yet keep on going and pulling the load behind it however slowly or inefficiently. The diesel locomotive will either go if it is in good order or just stop if everything is not right up to the mark.

America found to her cost that she had not enough diesel trained mechanics to maintain these locomotives on the line and in running sheds with the result that hold ups and stoppages kept on mounting with the result that trains could not be worked to schedule and abnormal delays became the order of the day. Analysis of failures showed that some were serious whereas others were due to just minor causes. The latter could have been put right by properly trained mechanics and the engine made fit to continue her task with some delay.

America was bold enough to take the right decision and that was to delay diesel traction by nearly 2 years and take in hand seriously and intensively the training of personnel required to maintain these more sensitive engines in a high state of efficiency.

Training of diesel mechanics from the lowest to the highest grade intensively became the order of the day. As the diesel engine mechanic had to look after and put right quickly a delicate piece of mechanism the best mechanics with initiative mechanical powers were selected in the first instance and put through the mill. These men from their working hours till the time they went to bed were thinking of nothing else but the intricacies of the diesel engines, diagnising defects and putting them right in the shortest possible time so that on passing out their final tests they were really good and capable craftsmen, who understood what they were doing and why they had to do it.

When America started Diesel Traction on a large scale the second time the thorough training imparted paid dividends. The failures were few and far between, the delays on schedule due to minor defects were small and the time lost could be made up by a good driver. Drivers were tuned to their engines and anticipated faults and were able to rectify them before a break down occurred. They knew where proper attention would be available and were able to nurse their engines upto that place, and further they were able to give the clues, whereby the highly trained mechanics could put their hand on the defect and rectify it in quick time.

Now this lesson of America has not been lost on the British Railways where large scale introduction of diesel locomotives is taking place on the 15 year modernisation plan. Many radical changes are being adopted in the existing methods of operation and maintenance.

A comprehensive training programme has been drawn up for all levels of staff who are or will be concerned with the provision, servicing and repair of this new form of motive power.

The programme is in two main parts. First a centralised syllabus of training is in operation at the British Railways Staff Training College at Derby for personnel upto the Officer level of the Chief Mechanical and Electrical Engineers Department, the Carriage and Wagon Engineers Dept. and the Motive Power Supdts. Department and applicable to staff of all regions.

Secondly, a series of driving schools have been established in the Regions for the training of drivers and fitters concerned with day to day operation and servicing of diesel powered locomotives, rail cars and multiple unit vehicles.

At the Staff Training College at Derby a large building accommodates the considerable amount of equipment required for training of Senior staff in the technicalities of the various types of diesel engines, mechanical, hydraulic and electrical transmissions, fuel injection systems and ancilliaries. A small room in the same building is set apart for the demonstrations of the fuel injection systems the heart of the diesel engine and by its side is a maintenance workshop. The staff attending the courses at the college are drawn from the three technical departments from the grades of mechanical Foremen, Inspectors and Assistant Works Managers and District Motive Power Superintendents. Theoretical instruction and instructional films are provided in the college class rooms and practical instructions and equipment demonstrations are carried out in the diesel wing.

About 20 to 30 students attend each course and 10 to 12 such courses are held per year. Courses vary in duration for the Foremen from the three technical departments upto 2 weeks and for Supervisory staff of locomotive sheds, Masters and such like upto 5 weeks.

Lectures are given by specialists representing equipment manufacturers and demonstrations by senior instructors who have specialised in the mechanical and electrical fields of diesel traction.

Similarly, in the divisions lectures and demonstrations are given under the Motive Power Superintendent of the division and drivers and fitters are given the knowledge both in theory and practice to carry out the day to day servicing diesel locomotives and other forms of diesel power vehicles.

On the Coras Impoar Erican or the Southern Irish Railways, when it was decided some years ago to switch over entirely to diesel traction orders for some 135 diesel locomotives had to be placed to replace the entire steam power. This programme of dieselisation is now being completed.

Servicing maintenance and repair facilities were recognised as being of prime importance and co-incident with placing of orders for 94 diesel locomotives in the first batch, steps were taken to acquire maintenance and repair equipment and plans for servicing points were laid on and are now being worked to.

Side by side with the planning for servicing and repairs of locomotives arrangements were made for the training of staff of all grades who would eventually handle the periodical examination at intervals of a week a month and three months. Besides this at their Inchicore Shops at Dublin scheduled overhauls were fixed and mechanics, supervisors and higher staff conversant with the intricacies of the diesel engines were already available. There has, therefore, been no hitch up to now on the dieselisation programme of the Irish National Railways.

India has had diesel locomotives for sometime now. First there were the diesel shunters on the Central and Western Railways. At this stage no precautions were taken to select and train special staff. The staff available were poor and insufficient so that shunting locomotive maintenance, repair and overhaul was by the hit and miss method. There were Railway Cranes powered by diesel engines which due to lack of knowledge of point to point examination driving ability, repairs and overhaul had to be put out of commission for long periods.

Since those early days the Western Railway has gone in for diesel locomotives for their branch lines at Saurashtra and operating in this area are about a dozen metre gauge locomotives which from the day they were installed have given considerable trouble. Some of the trouble have been caused by faulty design or equipment by the manufacturers who are a firm of repute in other parts of the world and whose diesel locomotives there have stood up to all tests imposed. In India they have been rather unfortunate and although they have flown out a number of experts and effected improvements the locomotives have not been found to be 100% efficient when working in undoubtedly severe conditions.

Now India has placed an order for a 100 mainline diesel locomotives from America. These are of the large kind weighing about 110 tons each and generating about 2000 B. H. P. A fifth of that order has materialised and the balance will follow and the order completed by 1958. The manufacturers of the locomotives are the Alco Products Inc. of U. S. A., a firm that has built diesel locomotives for many nations.

With the advent of these diesel locomotives, India will already have a variety of diesels on her hands and it is, therefore, important, nay I would say vital, that we have a sufficient number of diesel engineers, diesel mechanics and fitters, diesel drivers, service and repair men to maintain these locomotives at a high standard of efficiency.

It is not sufficient to train the personnel to maintain, repair and overhaul these engines but the number trained should be at least 30% in excess of requirements to offset retirements, deaths, resignations, sickness etc. Not only this arrangements should now be made to give these men refresher courses and examinations to see that their knowledge and experience is always keyed upto requirements.

Only if this is done and done in a systematic manner will we have diesel locomotives doing useful work on our railways rather than being ornaments or worse still a series of white elephants.

CENTRALISED TRAFFIC CONTROL

Effects maximum economy in operation of single and double tracks.

By H. C. Towers, M.I.E.E., M.I.R.S.E., M.Inst.T.

IN the early days of railways, telecommunications had not been discovered and the crossing of opposing trains on single lines and the spacing of following trains had to be regulated by a timetable. Strict adherence was essential if the service was to run smoothly and if a train was delayed other trains were held up as well and the service was disorganised. One of the greatest difficulties was that those responsible for operation had no idea which train had been delayed or where any of the trains were on the system.

The discovery of telegraphy and the development of the world famous code brought into successful service by Samuel Finlay Breeze Morse at Baltimore in 1844 brought a great improvement in train operation. Each station was connected to a telegraph circuit and instructions regarding train crossings and other matters were transmitted from a central co-ordinating point. In the U. S. A. there are many thousands of miles of single line railway worked on the train order or timetable system and these were soon converted to a dispatcher system in which instructions to train drivers were telegraphed to fixed points along the line where they could be halted by train order signals to receive the dispatcher's instructions.

Shortly after the first world war the traffic control telephone system was introduced and today it is in extensive use on British Railways and railways of the Commonwealth and other countries. The system divides a railway into traffic divisions each having a central traffic control office. Stations, signal boxes, engine sheds, railway officials, etc. are connected to it by omnibus telephone. For operational convenience each division is divided into two or more sections, according to geographical conditions, each section being supervised by an assistant train controller. These controllers can call individual stations by selective ringing each way station, as they are termed, being allotted a ringing key or push button. Although an omnibus circuit is used due to coding only the bell at the station called responds to the controller's action. Way stations attract the controller's attention by lifting up the telephone handset and announcing the name of the station or identity of the person calling. The assistant controllers are continually listening to the circuit by means of headphones. The chief train controller, who is in a room by himself, is provided with a desk type telephone since he is only required to speak to stations on special occasions or to converse with officials out on the line. He can select the section with which he wishes to converse by a special switch.

The wayside stations report to control the arrival and departure of trains and the assistant controller records their progress on a graph. On single line sections the traffic control office issues orders regarding train crossings where delays may necessitate departure from timetable arrangements. The preparations made at stations and speed of operation of point switches and signals is entirely in the hands of local operators and the controllers have no direct supervision of any kind. This difficulty is common to both the telephone and the train order method of control. In the U. S. A. endeavours were made to devise a system which would place the control of traffic on a section in the hands of a single operator. Several years were spent in patient experiments and finally, in 1927, the General Railway Signal Dispatching System was introduced on 40 miles of the Ohio Division of the New York Central Lines.

Centralised Traffic Control, as it is known today, is a supervisory control system whereby all train movements are directly controlled from a central point on the section from a place within it. With this system no intermediate operators are necessary because all points and signals on the section are operated from the central control office. Intermediate signals between stations work automatically. The points are operated by electric switch machines. Originally the signals were of the semaphore type, electrically operated. The arms operated in the upper quadrant and had three positions corresponding to the red, yellow and green aspects used in colour light signalling at the present time. In the U. S. A. these signals have since been replaced by colour lights. The section is track circuited throughout so that the position of every train may be known to the

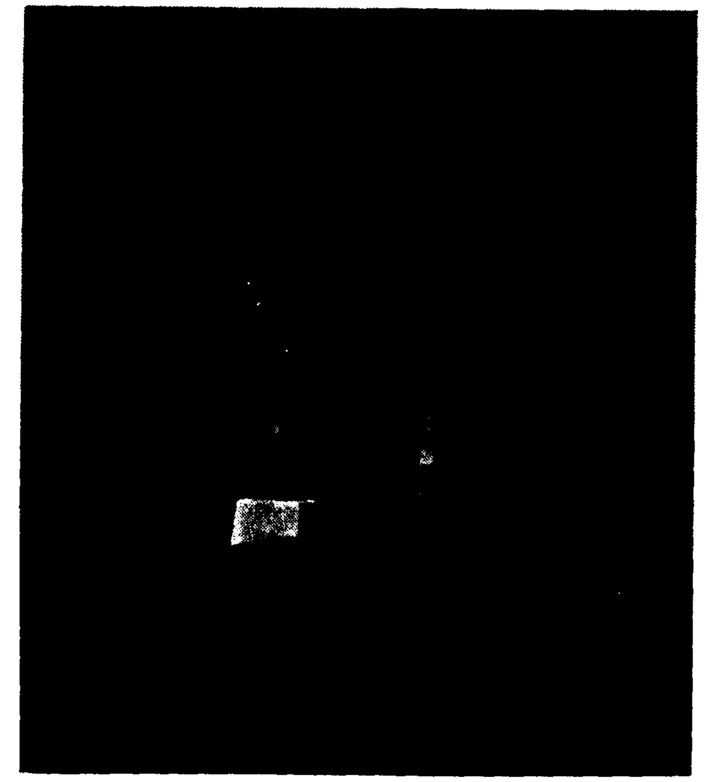
CTC operator and also complete protection afforded to every train on the section.

Each station remains as a separate installation with all the interlocking securities of an individual signal box. The CTC is merely a supervisory control or "long arm" and even though the operator may turn a key to cause a certain signal to show "Proceed" the signal will only respond if the line over which it reads is clear, points correctly set and locked and opposing signals showing "Stop". Only two line wires are required throughout irrespective of the number of stations controlled or the number of signals, points or track circuits in use. This is achieved by a system of coding similar in principle to the traffic control telephone system.

ADVANTAGES OF CTC

The traffic capacity of any section of railway can be represented in train hours. When the running time of a train is known, it is a simple matter to determine the theoretical train capacity. A reduction in the running time increases the train capacity. The more trains that can be run the greater is the tonnage that can be moved. CTC makes this possible because it reduces lost time. Where trains of different speeds are involved, which is ordinarily the condition to be met, various examples of single track operation with CTC have shown that the train capacity and running time have been quite comparable with the usual operation of double track ; examples of double track operation with CTC have shown an increased track capacity where one or both tracks have been signalled for either direction running where directional congestion is an operating factor. Experience and studies show that the track capacity has been, or may be, increased from an average of 28—30 and 50—80 trains per day on single track lines. Actual operation of 42—70 trains has been accomplished on several single track lines without difficulty.

Since the introduction of CTC in the U. S. A. in 1927 enormous developments have taken place and year by year more installations have been introduced. At the present time sections of from 100 to 200 miles are controlled by CTC and even longer sections will be used in the future. There are no CTC installations on British Railways though it is possible that this may be considered under the modernisation programme. Installations in Africa and New Zealand are giving splendid service and CTC is being expanded in these two countries and elsewhere.



Searchlight signal at station on CTC controlled section.

In the U. S. A. the use of CTC has brought great success to the conversion of double track lines to partial single and double track operation. The result is somewhat similar to crossing stations on a single line of railway only the stations are several miles long. This means that opposing trains can cross each other without one of them having to stop: fast trains can overtake slow trains, both travelling in the same direction. CTC allows these movements to be co-ordinated. The whole section being under the control of one operator permits great flexibility. The position of all trains is indicated and he is in a position to detect contingencies as soon as they arise and prevent or minimise delays. For example, two trains are approaching each other, several stations apart. According to their present rate of progress, the operator has selected the station where they will cross. One train becomes delayed and would be considerably late in arriving at the selected crossing place. This would cause an even greater delay to the second train. CTC helps the operator to quickly appreciate the situation and he is able to change the crossing place enabling the second train to proceed still further on its journey without delay.

On railways with only double tracks in their suburban areas and on which both local and express trains have to travel, delays occur to the latter when they overtake the slower moving local train stopping at all stations. These delays can be removed by signalling both tracks for reversible working. For example, an up express is likely to be delayed by an up local. The signalling permits the express to be diverted to the down line to overtake the local. It is then switched back to the up line at the first convenient place. Such movements can be carried out with ease and safety with the use of CTC.

Engineering work trains or specials, regardless of whether they are starting from a terminal or are on the road, offer no operating problem in CTC territory for they can be run from point to point without time consuming preliminaries. With CTC a train is run just as far as it is convenient to do so—if there is time for it to reach the next crossing station, it is sent on.

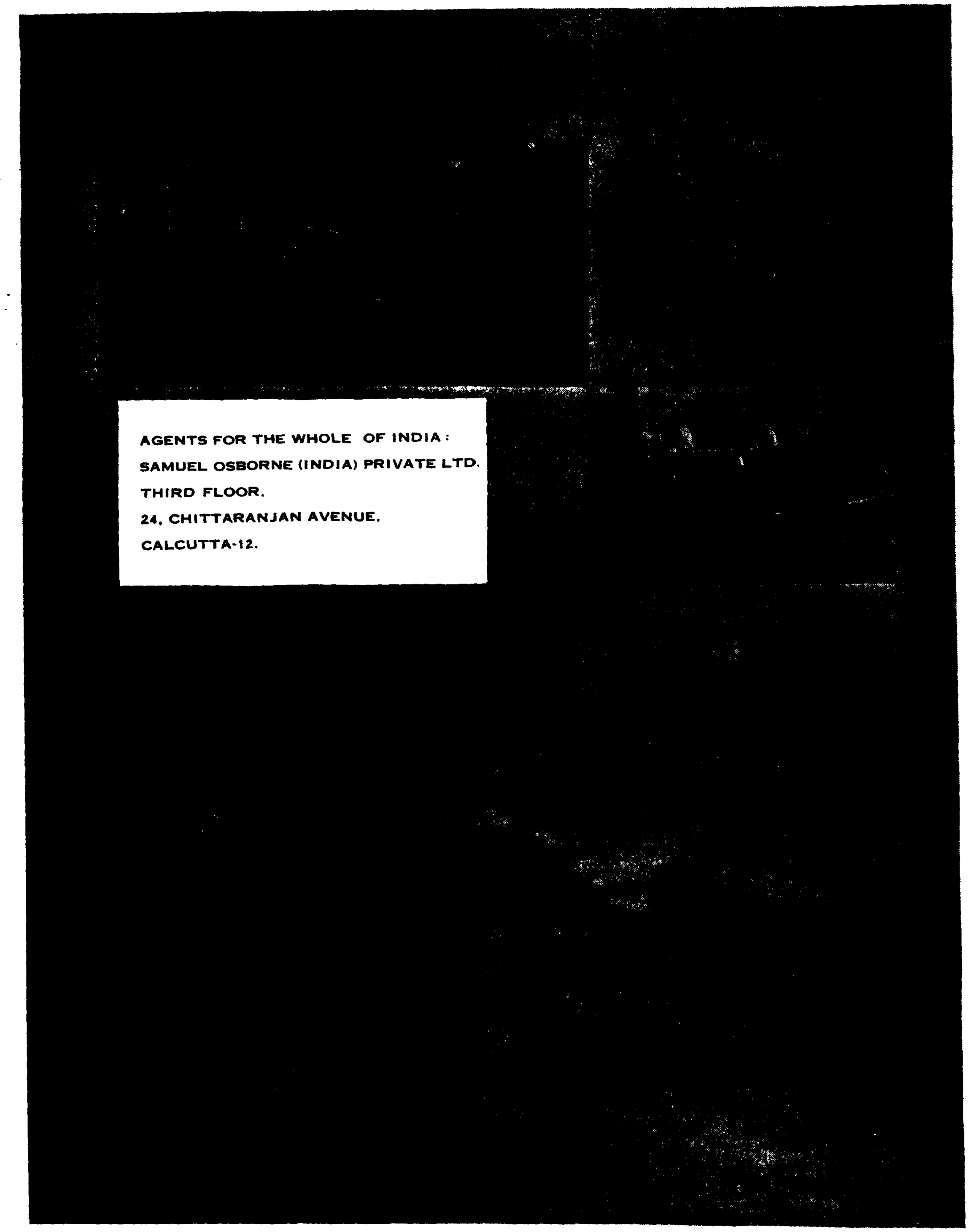
The introduction of CTC has made it possible to postpone the construction of additional tracks to obtain increased track capacity or improved operation. This feature is specially valuable in congested places where additional right of way cannot be acquired or at a reasonable price, or due to special local conditions. A single line railway running through many miles of rock cutting would be an example where great saving could be effected by overcoming the necessity for doubling which would entail blasting and heavy engineering work.

CONTROL PANEL

The CTC operator has a control panel on which is depicted a plan of the whole section in his charge showing stations, sidings, etc. Each track circuit is shown on the panel and is fitted with a miniature electric bulb which is illuminated when the track circuit is occupied. The operator therefore has a complete picture of the whole section, can see the position of every train and note its progress. Signals and points are operated by miniature thumb switches placed on the panel under the plan and beneath the signal or points they control. The appearance of the track plan and switches can be seen in the photographs. The shape of the panel varies with the number of stations controlled. If there are only a few it would be flat and could be mounted on a desk or made as a floor cabinet. CTC sections may be over 100 miles in extent and in such instances it is usual for the panel to be U shaped so that all switched are within the operator's reach and it is not necessary for him to leave his seat.

With a crossing station consisting of a single loop only two switches are required at each end of the representation of it depicted on the panel. One switch controls the points and the other the signals. The point switch has two positions, normal and reverse. Two small lamps are placed above it one having the initial N and the other R engraved on it. These visuals indicate that the points are correctly set and locked, either normal or reverse, according to switch position. The signal switch is normally central and signals are cleared by turning it either to the left or to the right depending on whether a train is being dispatched or received. Visual lights repeating the signal aspects may be provided according to an individual railway's requirements. A small red light over the signal switch would indicate that all exit and admission signals at that end of the station were showing stop. The turning of the signal switch to the left, or right, would extinguish the red visual and illuminate a green visual either at the left or right of the switch. The lighting of this visual indicates that the signal is showing one of its proceed indications (yellow or green) and also that points are correctly set and locked and opposing signals showing stop. Beneath the signal and point switches is a start button which is pressed to initiate point or signal movements.

To explain the operation, it is assumed the operator wishes to receive a train on the loop line at a station. Providing the track circuits protecting the loop line and the points are clear, he turns the point switch from N to R and the signal switch towards the direction in which the train is approaching. The operation of the start button causes the points to reverse and the admission signal to clear. On the panel the N light is extinguished, the R light illuminated, the red light extinguished and the appropriate green light illuminated. This explanation is given as an example. The method of indicating signal and point positions varies with the manufacturer of the system or a railway's individual requirements. In some cases the normal position of signals is not indicated, a green light only appearing in the centre of the signal switch when turned left or right and the start button operated. As an alternative to the normal and reverse indication visuals, switch operation is indicated by the "out of correspondence" method, that is, when the switch position corresponds to the switch lever position, the indication light is out. When out of correspondence the light is either flashing or steadily illuminated.



Other then crossing loops, sidings at stations are usually worked locally. Their point switches are hand worked and locked electrically by the CTC. If vehicles are to be shunted in or out of a siding, the operation of a special switch on the CTC panel releases the hand lever. The points are then worked by one of the engine crew. During this time the CTC operator is "locked out" and he is unable to operate the points and signals at the station. When the shunting movement is completed, the man working the hand lever restores the points to their normal position and returns the release to the CTC operator.

With the traffic control telephone system, each station reports to the assistant controller the time of arrival and departure of each train. These timings are sometimes inaccurate especially if the person on duty has other duties to perform. In the CTC system, automatic train graph recorders can be incorporated in the desk portion of the control panel, or in a separate unit close to it. These recorders are operated automatically by the passage of the train out on the section and they can record timings at as many stations as may be required.

FIELD EQUIPMENT

Signals at CTC station are usually of the colour light type and may be of the multi-aspect or searchlight type. In the U. S. A. the searchlight signal is mostly used and these can be satisfactorily operated from primary batteries where a power supply is not available or from secondary batteries on low rate charge where power is at hand. Points are worked by all electric point machines which drive and lock the point switches and also electrically detect that they are correctly set and locked. Machines can be supplied incorporating a hand lever and electric release enabling the switches to be thrown by hand by the train crew providing the CTC operator has electrically released them.

The signalling and interlocking relays may be concentrated in suitable accommodation in the centre of the stations or placed at each end near the points. A small hut is suitable for this purpose which could also accommodate the CTC relays, batteries and other equipment.

The use of only two line wires throughout CTC territory is made possible by the use of coding equipment. Each function initiated from the control panel sets up a code through a system of relays which transmit the code to line. The CTC territory outside the control office is known as the "field" and the CTC relays at stations are known as "field units". The function of the field unit is to decode the impulses received from the control panel. They also return coded impulses to the control office to indicate the condition of points, signals, track circuits, etc.

CTC can be applied to existing signalling systems provided that track circuits are installed and main line running signals and points required to be operated from the central control are electrically operated. Existing signal boxes may be retained for shunting and operation of points and signals not connected with the main line. They would be normally switched out the CTC operator working main line signals and points from the panel. If shunt movement affecting the main line have to be carried out the CTC operator releases the signal box and a station operator or signalman operates points and signals from the lever frame. During this period the CTC operator is "locked out".

CONCLUSION

In countries such as Africa and India there are very many miles of single line railway worked either by token instruments or paper line clear through local telegraph circuits. Often the signals and points at stations are worked by hand levers. Much delay occurs in signalling trains from one station to another and in signal and point operation where trains have to be crossed. This often means that important goods trains have to be laid up on sidings for hours until there is a path for them resulting in increased fuel consumption, increased staff costs, delays to freight and many other losses.

CTC overcomes all these difficulties and provides absolute direct supervisory control over train movements and ensures that they are carried out with the minimum delay. The location of all trains on the section can be seen at a glance and it is unnecessary to loose time in calling and questioning some distant operator or in transmitting instructions regarding train crossings. The elimination of distant operators removes the opportunity for division of responsibility and misunderstanding.

In tropical countries the increasing use of steel sleepers has restricted the use of track circuits to station yards only. The use of steel sleepers between

(Continued on page 11)

Industrial Trucks Working with Railways

ALL those concerned with the transportation of goods whether by road, rail or sea should today be fully alive to the possibilities which exist for increasing the safety and speed of their services by the use of modern handling equipment. This is particularly important since a very large percentage of the millions of tons of freight carried every day passes through goods depots, or into and out of sheds and warehouses. Although this article is written with particular reference to Railway use, most of it can equally well be applied to road and sea traffic. It is found that road traffic can frequently complete delivery of goods without a great deal of handling en route; on the other hand, rail and sea traffic often requires considerable handling before reaching its destination, and the degree of efficiency that can be achieved in loading and unloading ships at docksides, is a critical factor in ship turnround time.

Fig. 2

It is an established fact that one of the largest single contributors to a faster and more efficient

Fig. 1

movement of transported goods is the Forklift Truck. This is a veritable maid of all work which can be used in conjunction with conventional forks or with an ever growing range of attachments, such as the hydraulic clamp, (for packing cases, wool bales, jute, etc.) barrel clamp, rotary paper reel clamp, crane attachment and ram or bar attachment (for handling steel coils, tyres etc.), and which can tackle almost any handling problem. In fact, in certain cases it is even common practice to lower forklift trucks into ships holds for handling freight in awkward corners and placing it under a crane for discharge. In such circumstances battery powered trucks, with their low fire risk and absence of contaminating exhaust fumes, are absolutely vital.

Coming now to the particular application of forklifts to Railway use, reference to Fig. 1 will show a 2-ton capacity forklift truck unloading freight from railway wagons in a goods yard. The freight can then be transported to a warehouse and if necessary stacked to roof height; all these operations can be carried out

(Continued from page 10)

stations would not prevent the installation of a CTC system since axle counters, which take the place of track circuits, are now available.

In future years it can be foreseen that CTC will be even more extensively used and very much longer lengths of railway controlled from a central point. The use of coded systems operating from ordinary route relay interlocking panels is developing rapidly enabling distant interlockings to be worked over a pair of line wires in place of a large number of cables that were necessary in earlier systems.

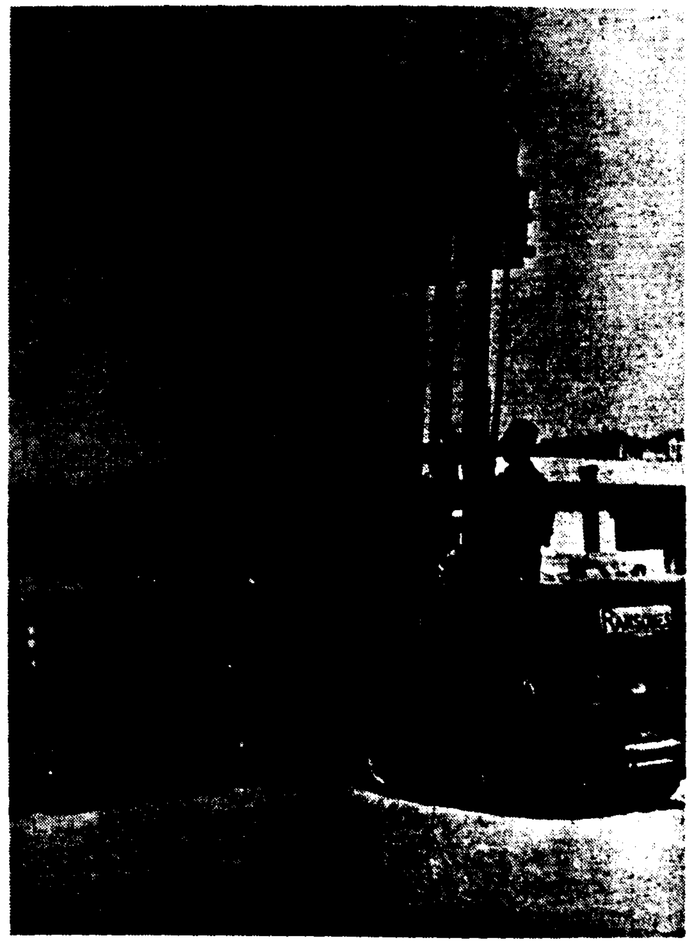


Fig. 3

by the one machine, thus affording speedy availability of wagons with a consequent saving of demurrage. The forklift truck's almost universal use can be more readily appreciated by reference to Fig. 2 which shows bales of jute being handled by a 1,000 kg. truck and Fig. 3 which shows a Ransomes 2 ton capacity truck handling bales of cotton in Calcutta, both trucks being equipped with hydraulic load clamp. Fig. 4 shows a 500 kg. capacity forklift truck operating inside a railway box car; this small truck is capable of manœuvreing palletised goods inside this car so that all available space is utilised, thereby eliminating the use of an additional pallet truck.

Here it can be mentioned that although there are several ways of building up unit loads to make them suitable for modern methods of materials handling, the most universally adopted is the double sided flat pallet. Pallets can be obtained in various sizes to suit any type of goods and are usually made of wood or sheet steel. There are three main types, of which the two way entry pallet is open only at the front and back, with full length slats at the sides. The

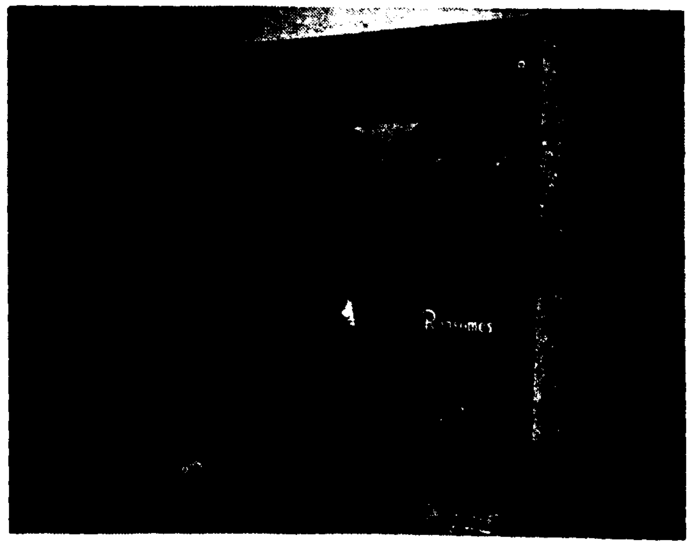


Fig. 4

Fig. 5

four way entry pallet allows the forks of a truck to enter any of the four sides, and there is the eight way entry type which, in addition to allowing the forks to enter the pallet on all four sides, can also be

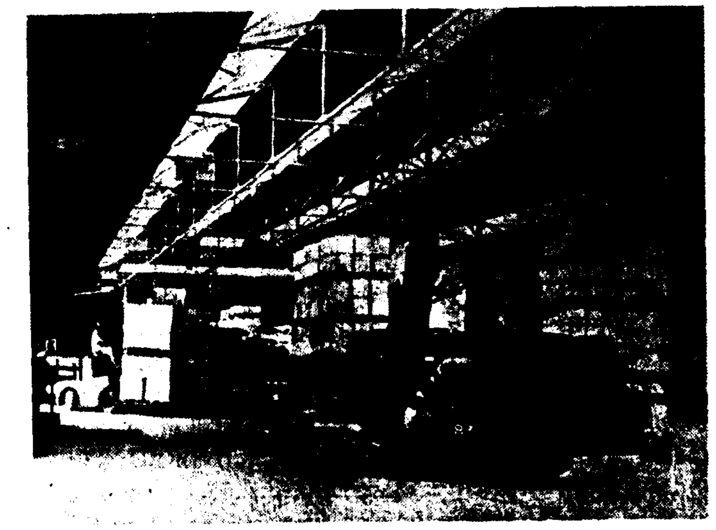


Fig. 6

Fig. 7

entered diagonally. Although flat or deck pallets as illustrated in Figs. 4, 5, 6 are the commonest in use, there are many special types for particular purposes. For fragile goods, unable to take the weight of the stack,

Fig. 8

post pallets are used. These are similar to those illustrated in Fig. 7 and it will be seen that the weight of the stack is taken on four posts at the corners of the pallet. Specially shaped feet assist the correct interlocking of the pallets. These pallets can be converted into box pallets by fitting side panels of steel, as shown, or of wire mesh for easy examination. Many other special types of pallets have been evolved for special loads, such as bar material, or awkwardly shaped objects and in all cases they ensure uniformity of size for handling and facilitate the building of a neat stack.

Fig. 5 and Fig. 6 show some different types of unit loads arranged for handling with forklift trucks working in modern palletised warehouses, the latter being operated by the Landing & Shipping Co., of East Africa; it will be noted that the palletised cartons are being stacked right up to the height of the roof girders. In every mechanical handling system it is as well to remember that the forklift truck is essentially a stacking machine and has a high ratio of tare to laden weight; therefore, where fairly long distances have to be travelled, it is good policy to employ platform trucks or a trailer train in addition to the forklift trucks. One of the best methods adopted in this connection is to operate one forklift truck at the unloading end and another at the stacking end, leaving the transportation between to be undertaken by load carrying trucks, or tractors and trailers.

It will, therefore, become apparent that most handling problems must be considered with due regard to existing local conditions; particularly is this so when considering dockside work. A typical example of these problems is one which occurred in the London docks. Here a large quantity of bagged sugar had to be unloaded from the hold of a ship and four cranes were available on the dockside for the job. Sufficient dockers were in the hold of the ship to arrange the bags of sugar in slings of unit loads of approximately 1,500 kgs. each, and the time taken for each crane to lift and deposit its load was roughly two minutes. It will therefore be seen that with four cranes a load was ready for transportation every half-minute. The warehouse for storing the sugar was approximately 200 metres from the dockside and it was decided to employ a fleet of platform trucks for covering this distance. It was very important to ensure that the correct number of trucks were employed to keep in step with the unloading of the ship. The time taken for a round trip to the warehouse and back was four minutes and, as each load was available at the ship's side every half-minute, eight platform trucks were necessary to maintain this time cycle. Actually nine trucks were used in this particular case, as it was most important to avoid any delay in clearing the cargo for the cranes. With this arrangement 180 tons an hour were unloaded, transported and stored. The total tonnage for a single day of eight working hours being 1,440 tons. Fig. 8 shows the Ransomes Stevedoring battery powered truck which has a large platform area and which is ideally suited to the exacting conditions encountered in this class of work. In the illustration an engineer is seen examining the battery which is situated under the platform and is easily accessible. In Fig. 9 the use of trailers with platform trucks can be seen. In this instance the loads are comparatively small and in consequence the truck is quite capable of towing two trailers in addition to its own load. In fact platform trucks are often used to tow trailers, the combined loads of which often amount to more than double the capacity of the truck alone.

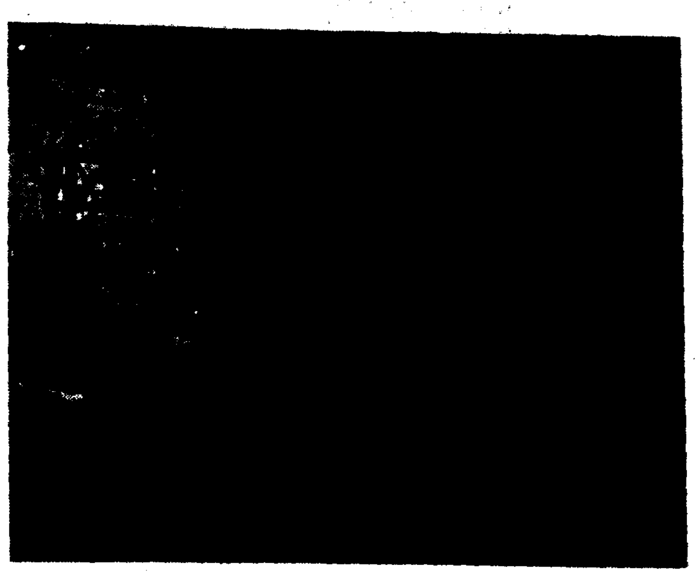


Fig. 9

A similar application to the one in operation at the London docks is to be found at the British Railways depot at Birmingham. Here twentyfour Ransomes NU4 platform trucks with fixed platforms 46 cm. high, and measuring 206 cm. in length and 107 cm. in width, are kept constantly at work dealing with incoming road traffic for onward transmission by the railways. The volume of traffic for this highly industrialised area is very large and the goods must be quickly distributed to the various sections to avoid congestion. The freight is unloaded from the lorries on to the platform trucks and taken to a shed for sorting into the numerous districts served by this particular railway. The consignment for each district is then carried by the platform trucks to the appropriate 'goods outward' bay, in readiness for the next available train. It will be obvious even from this brief description, that this fleet of 24 truck serves a very useful purpose, and although the total tonnage carried per day varies enormously and would be difficult to estimate due to the difference in size and weight of the individual packages, the efficiency and economy of the system are very apparent. We would emphasise in this connection that the overall working conditions of the people employed are made very much easier and this leads to an all round improvement in efficiency.

One of the principle items of freight carried by British Railways is mail for the Post Office, and, owing to the special nature of this freight, somewhat different handling methods are called for to ensure the least possible delay in delivery. The mail bags containing letters and parcels, being very bulky but fairly light, occupy too much space on ordinary platform trucks, and tractors towing twenty or more trailers have proved to be the best answer to this problem. The Ransomes T4 battery powered tractor has proved itself an ideal piece of equipment for this particular job. This tractor is of modern design, being mounted on pneumatic tyres, and in fact drives like a motor car. For handling passenger luggage and parcels traffic in confined areas the smaller Ransomes TE Tractor has the necessary manœuvreability and has proved itself highly successful when applied to work of this nature; it is only 178 cm. long with a turning radius of only 152 cm. and yet has a towing capacity of 2,500 kgs. A further advantage not always appreciated is that, where tractors hauling trailers are being operated under suitable conditions, three trains of trailers, one loading, one unloading and one in transit, can be employed, requiring only one tractor.

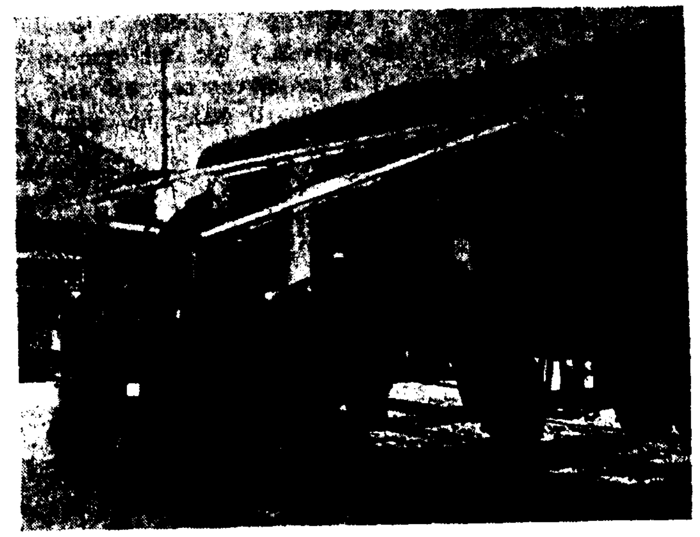


Fig. 10

Fig. 11

All railway systems must of necessity use cranes of one type or another and reference to Fig. 10 shows a battery powered mobile crane. This is the Ransomes L20 which is capable of handling one ton loads and is seen operating in a goods yard, placing a heavy crate in a covered rail van. This crane was originally designed to cover the growing need of the Railways for a runabout crane that would search enclosed wagons. The length of the jib is sufficient to reach through the doorway into the far corners of the vehicle, and at the same time will give a satisfactory height of lift over the side of open wagons. A similar model having a capacity of 1½ tons is also available and both are able to work from either platform or road level; furthermore the hoisting wire is sufficiently long to allow the hook to be lowered 3 metres below the ground level of the crane. The full rated load of the crane can be carried at the maximum radius with complete stability. The operation of these cranes will be better understood from this brief description; the crane is supported by four pairs of wheels; the front and back pairs of wheels form the steering wheels, both pairs being turned simultaneously by the steering gear. The two pairs at the sides are driving wheels and do not swivel; the outer one of each pair is driven through a reduction gear by an electric motor, which is spring-supported at one end from the chassis. It should be noted, however that the front and rear wheels in addition to being used as steering wheels, up to definite limits in either direction, may be further rotated when the crane is at rest, so as to be at right angles to their normal running positions. When the steering wheels are thus placed at right angles, one of the traction motors is automatically reversed so that the crane is capable of rotating around its centre on its four pairs of wheels for the purpose of slewing the jib. This provides all the advantages of a fully slewing crane without the necessity of providing a turntable, with all its attendant complications.

Fig. 12

Further savings in time and labour on Railway goods handling accrue from the use of a Ransomes ITW Shunting Tractor shown in Fig. 11. A special rigid 4-wheel drive provides exceptional adhesion on the various types of surfaces found in sidings and shunting yards. Power steering through a differential gear gives remarkable manœuvreability for working in confined spaces and facilitates the splitting up of lines of wagons. The tractor has ample power for handling one or more fully laden wagons, according to conditions, that is to say gradients, radii, state of track. The drawbar pull is 500 Kg. at 2 K/h, 300 kg. at 3.6 K/h, or 200 kg. at 7 to 8 K/h. Heavier loads can be pulled by means of a built-in winch giving a line pull of 1500 Kg. at 15 cm. per second. The winch also enables trucks to be pulled across junction points Fig. 12 thus avoiding the necessity for the tractor to cross exposed rails. The tractor can be fitted with equipment for such work as yard sweeping, snow clearance, stockpile trimming, and pumping water for flushing out wagons; trailer loads up to 6 tons can be hauled with ease. A choice of petrol or diesel engines is available.

In conclusion we would like to state that although only a limited reference has been made to mechanical handling equipment with particular reference to trucks, we feel that this article will have at least shown what can and has been done in this field.

INDO-RUSSIAN TRADE

The Indo-Russian agreement which was signed on Dec. 2, 1953, is valid for a period of five years. The Schedule "A" which lists the items available for import into India from Russia, zinc has been added. The chief items of imports from Russia mentioned in the Schedule are: iron and steel manufactures, metals other than iron and steel, mining equipment, heavy electrical plant and equipment, machine tools, ball and roller bearings. Since the signing of the Agreement in 1953, Indo-Russian trade has increased steadily. While the total trade between the two countries stood at Rs. 1.75 crores during 1953–54, the figure for 1956–57 was Rs. 32.41 crores. India had a favourable balance of trade to the extent of Rs. 55 lakhs during 1953–54. During 1956–57, however, the balance of trade was against India to the extent of Rs. 1.41 crores. This was mainly accounted for by large imports of iron and steel products comprising nearly 80 per cent of Russian exports to this country.

Hydraulic Presses for Cold Bending Steel Rails & Sections

AN important item of equipment in all railway workshops is the horizontal bending machine. Whether mechanically driven or by hydraulic power, these machines are readily adaptable for hot or cold bending and forming of track components, section straightening and curving, correction of distortion in welded assemblies and tube bending.

Although the mechanically driven machine has been longer in the field for this class of work, various features on the hydraulically powered press have recommended it as a more reliable unit. With greater protection against overloading and more control over operation pressures, the hydraulic 'bulldozer' or horizontal press, has been brought more and more into use for components in fabricated construction work. With the hydraulic system combined in the press head, as opposed to a cylinder operating from an accumulator system, very high powered compact machines are possible and space requirements reduced to a minimum.

Finlay Engineering Ltd., Newport, Mon., England, have, for many years, manufactured a range of hydraulic presses, both horizontal and vertical, for such work, and their machines are in use in British Railway workshops, as well as in a number of other plants manufacturing railway equipment in the U. K. and abroad. Fig. 1 shows Model R100. EB horizontal press arranged with standard blocks and reverse bending head for cold bending rails up to 120 lbs/yd. Special stepped blocks can be supplied for flanged rail sections. Although only requiring a floor area of 8'6" × 3 feet, the machine is robustly constructed, and with the pump unit and electric drive combined with the cylinder arrangement, is ready for operation by a simple connection to the power supply. No special foundations are required, only a reasonably level floor to carry the weight of the Press, which is approximately 5 tons. In some shops the whole machine is mounted on wheels for portability, so that track work can be carried out in the yard where there are less space limitations.

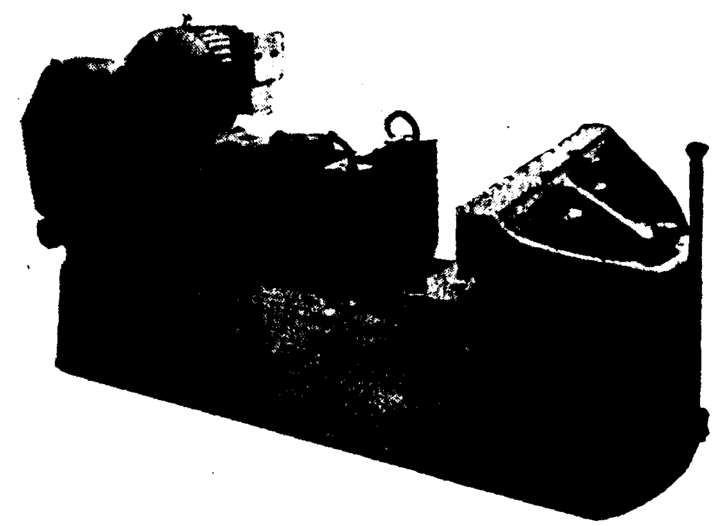


Fig. 1. 100 ton Bending Machine for Rail Sections (see paragraph 3)

The triple plunger oil pump unit is driven by a 7½ H. P. electric or compressed air motor, and the hydraulic system is protected by a blow-off valve. Operation is by a simple operating lever which is situated at the end of the machine so that the operator can oversee the work and be protected against the possibility of rail breakage.

Finlay Engineering Ltd. manufacture similar models of 40 tons and 70 tons capacity for lighter work, and also vertical presses up to 150 tons capacity. Figs. 2, 3, 4 & 5 show examples of various models, from which it will be seen that in addition to railway work, these very versatile machines have wide applications in general engineering. In constructional work, the RG100 model has a capacity for bending or straightening rolled steel sections up to 24" × 7½" joists, and the PB100, with its cut-out bed, is suitable for plate flanging up to 1/2" thick × 36" wide. The 40 and 70 tons models represented in fig. 4 are the smallest and most compact machines produced by Finlay, and have been designed for reconditioning the bent and twisted steelwork arising from ground pressure in collieries and mines.

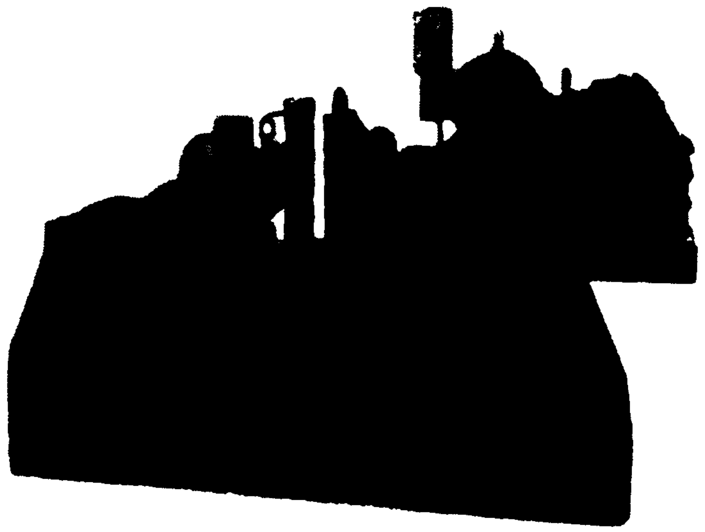


Fig. 2. R. G. 100 Press for Deep Sections (see paragraph 5)

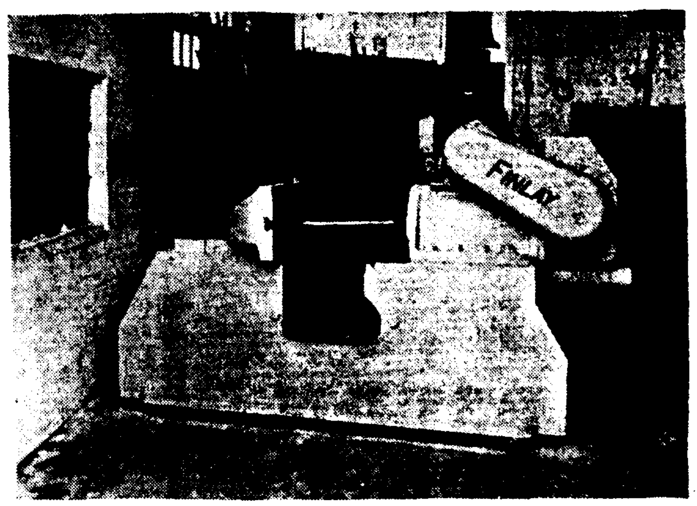


Fig. 3. 100 ton Plate Bender. Model PB 100 (see paragraph 5)

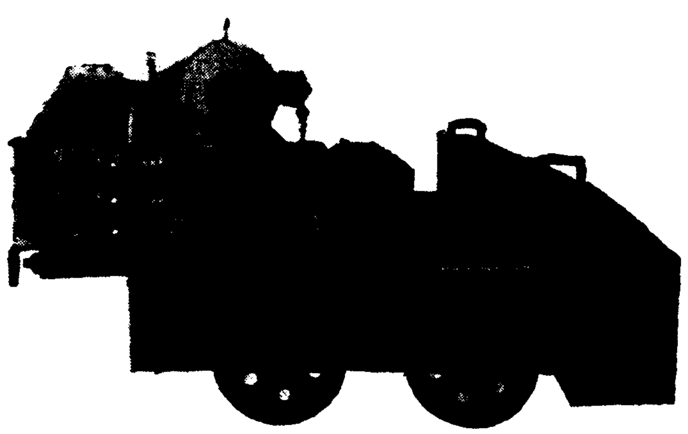


Fig. 4. 40 ton to 70 ton Mining Type Press (see paragraph 5)

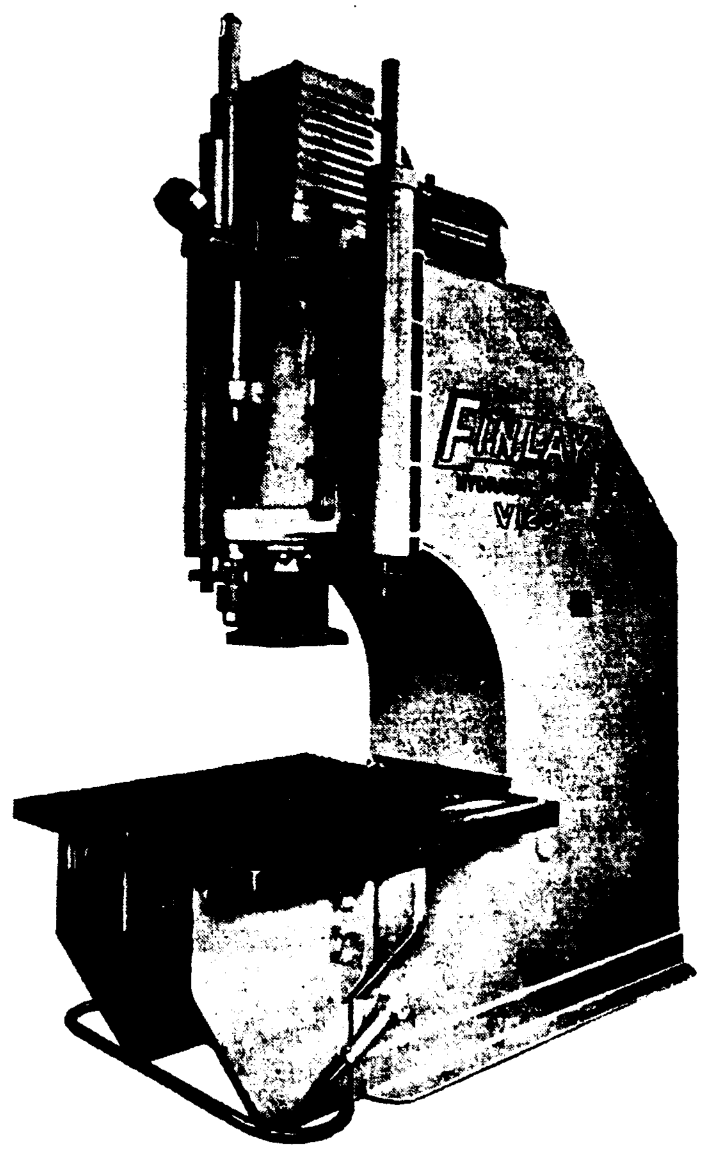
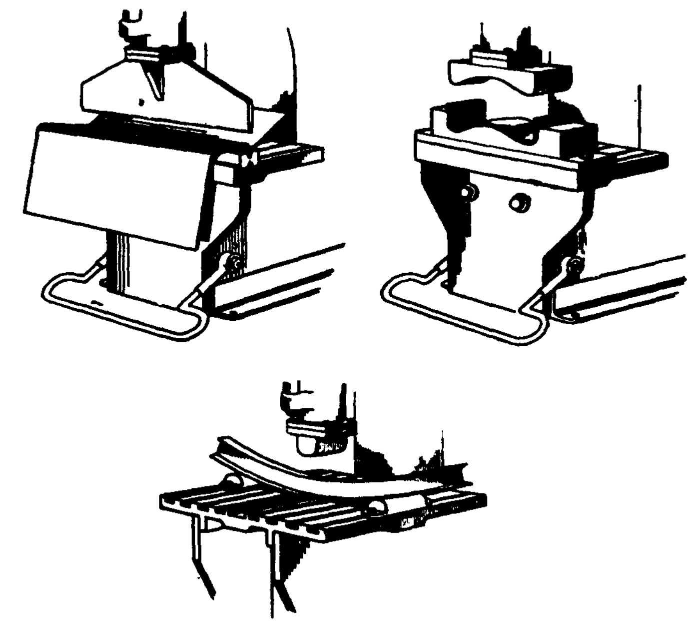


Fig. 5. 150 ton Vertical Hydraulic Press (see paragraph 6)

Fig. 5 shows the standard 150 tons vertical hydraulic press, which is designed as a general purpose plate and section bender with a capacity for plates up to 5/8" thick × 48" wide. A unique feature of this press is the removable half table which reduces the full table area of 48" × 48" to approximately 30" × 48", and so permits reverse bending of plates and sheets in a manner similar to that on a press brake. The three small figures Fig. 6 illustrate different arrangements of work that can be carried out on this machine.

In addition to the standard types of presses photographed here, Finlays have produced many presses of



3 illustrations of different arrangements of work that can be carried out of the vertical press (see paragraph 6)

special design to suit specific applications, such as machines for loco and carriage spring bending, spring stripping and loco component assembly.

The simple design characteristics of Finlay machines recommend them particularly where only semi-skilled labour is available for operation and maintenance, and their robust—yet compact construction, provides a concentration of power in machines designed for long service. All machines supplied in the export market are shipped with a set of recommended spare parts, so that customers will be in a position to deal with normal wear and tear requirements without any great loss of production,

INDIAN EXPORTS TO GERMANY

According to a statement in the Indian Parliament, 110,893 tons of Indian manganese ore were exported to Germany in the first half of 1957.

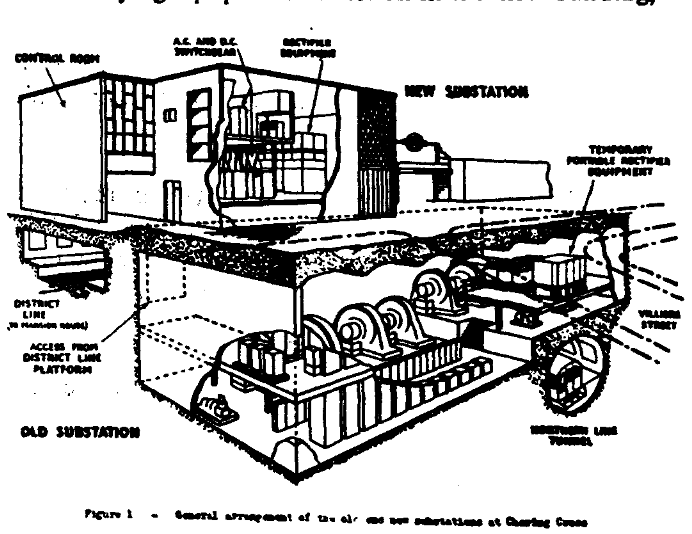
New Substation at Charing Cross replaces 50-year-old Equipment & Accommodation below ground

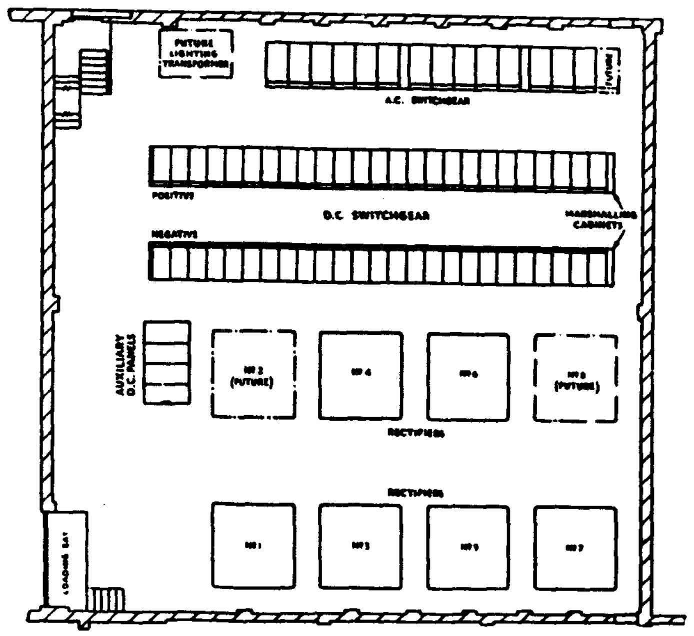
THE original sub-station at Charing Cross was opened in 1905 for the electrification of the District Railway, with provision to feed current to the Bakerloo and Hampstead Tubes, then under construction. A new substation built by London Transport to replace the original substation and the worn-out and obsolete equipment brought into use 52 years ago, was shown to the Technical Press.

The new station, which will eventually feed three Underground lines—District, Northern and Bakerloo —is at present operating up to about two-thirds of its capacity and the changeover to it from the old plant is being carried out in stages to avoid any interruption to passenger service.

Many problems have had to be overcome by London Transport in building and equipping the new station and at the same time maintaining a permanent current supply for running the trains.

But now, with the first four of six sets of mercury arc rectifying equipment in action in the new building, London Transport electrical engineers are in sight of the end of a long period during which they have kept obsolete rotary converters operating in the most cramped and difficult conditions.





Ground floor layout of the new substation.

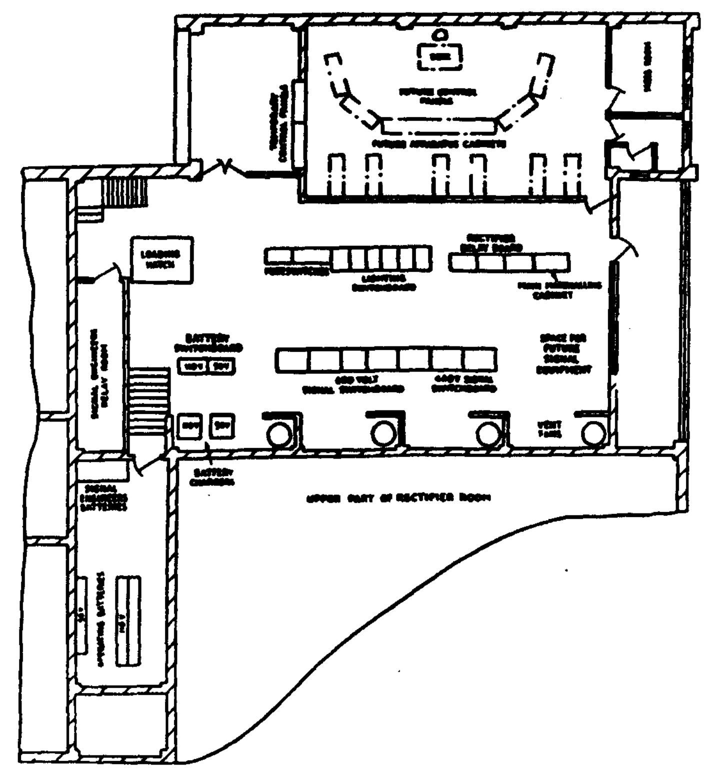
The new substation which should be in full operation for traction supplies early next year, represents another step forward in the modernisation of London Transport's power supply services.

The old substation, which is fed from Lots Road Power House at 33⅓ cycles, was built below ground level, with four 1,500 kW rotary converters. A fifth rotary of the same capacity was added ten years later and the sixth, with a capacity of 2,500 kW, in 1921, making the substation the largest on the Underground system. All the D. C. switchgear is the original equipment.

(Continued from page 21)

Plant Committee appointed by C. W. P. C. recommends that where the earth work is cheaper by 20% or more with the machines; the machines must have the preference. But we find that if the machines are properly used these can be much more cheaper than the manual labour.

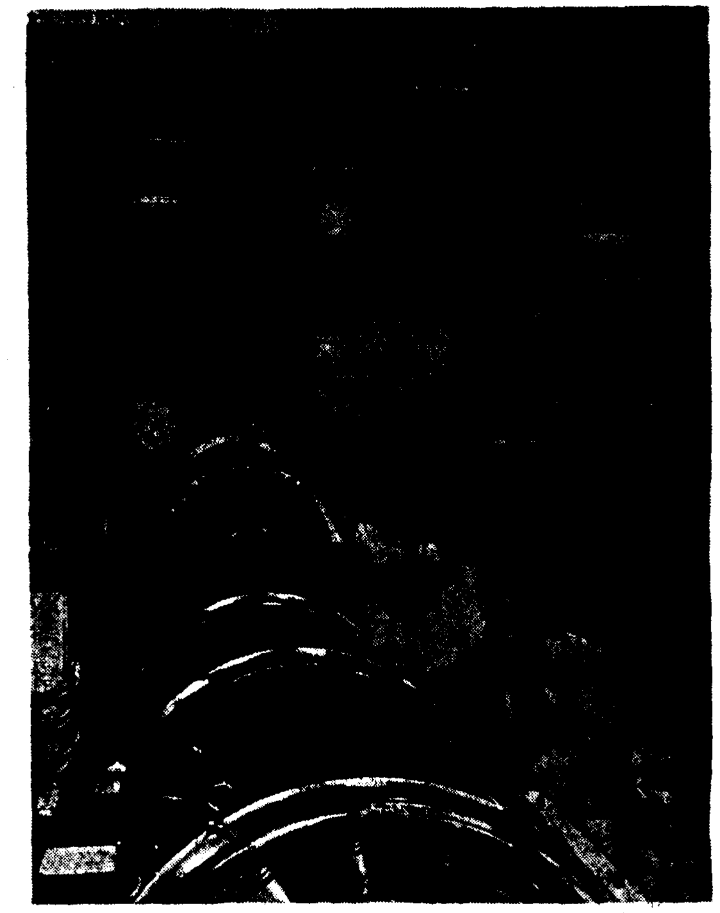
As the world is moving fast—India is bound to move fast and to achieve its Five Year Plans it has to look forward to manufacturing these machines in India.



Upper floor layout of the new substation.

High-level view of the new Charing Cross substation building from N.W, showing the loading bay entrance, with the 'Exit' footbridge alongside.

The new substation, which is wholly above ground, is fed from Greenwich Power House at 50 cycles, via Aldgate Switch House, and is being equipped with rectifying units totalling 9,000 kW. Space is available for two more 1,500 kW units to meet possible future requirements. Ignoring the provisions for future



Five of the six rotary converters in the old substation below ground. Part of a 1,000 kW portable rectifier unit being moved into position at right to replace the furthest rotary which had failed.

expansion, this means that 9,000 kW of modern equipment will be doing the work previously done by 10,000 kW.

As with all London Transport's recently modernised substations, unit construction has been adopted for the new rectifiers as this offers the maximum portability and flexibility in assembly and enables the sites available to be fully utilised. The design has been evolved from the original portable units specially produced in 1948 by the Hackbridge & Hewittic Electric Co. Ltd., to meet the onerous requirements of the London Transport railway services. An example of the use of such versatile equipment can be seen in the old Charing Cross substation at the present time.

TEMPORARY EQUIPMENT

Shortly after the order for the new Charing Cross substation plant had been placed four years ago, a

Rectifier room in the new building showing Nos. 4 and 6 rectifier sets at left and Nos. 5 & 7 at right.

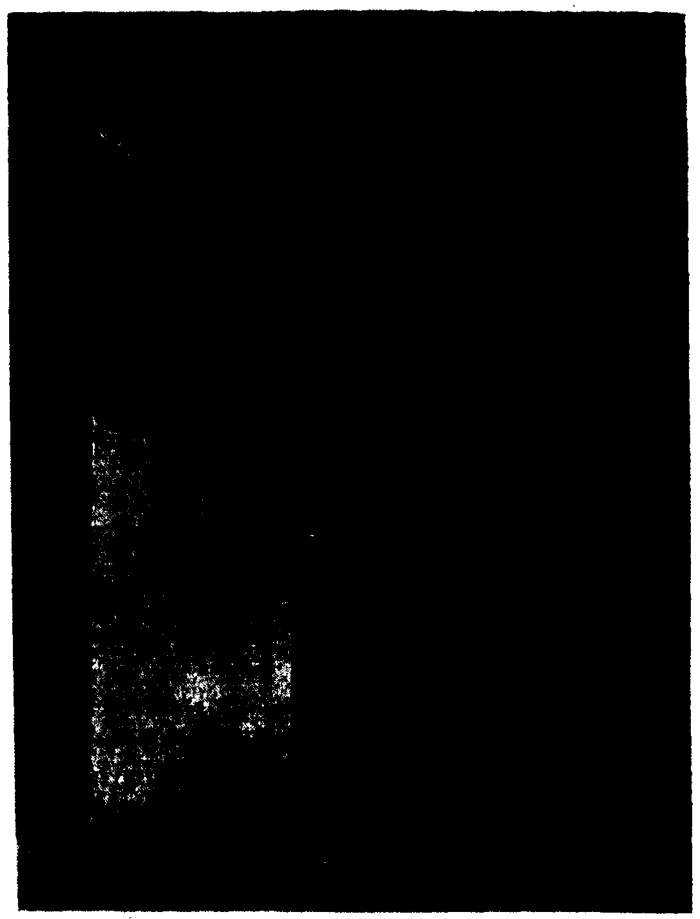
serious breakdown in the transformers of the largest rotary converter put that set completely out of action. The cost of repairing the transformers could not be justified, in view of the impending replacement programme, but in the meantime, it was imperative to restore, as far as possible, the 2,500 kW loss in substation capacity. This was achieved by the temporary installation of two of the original 1,000 kW portable units and coupling them together electrically to form one 2,000 kW set. The damaged transformers were removed from the building, but the site difficulties and necessity for maintaining the current supply precluded the removal of the rotary, and all that could be done was to pull the armature partially out of the machine, thus helping to provide space for parts of the portable rectifier units. The two units have been tucked in piecemeal wherever there was room; some parts are by the defunct rotary and some on the switchboard gallery. The installation of these units presented considerable problems, bearing in mind the restricted access and necessity for non-interference with passenger traffic, and the whole operation took nearly three months to complete. This compares with the three days in which the very first of these portable units was put into service in an emergency on a clear site.

THE NEW BUILDING

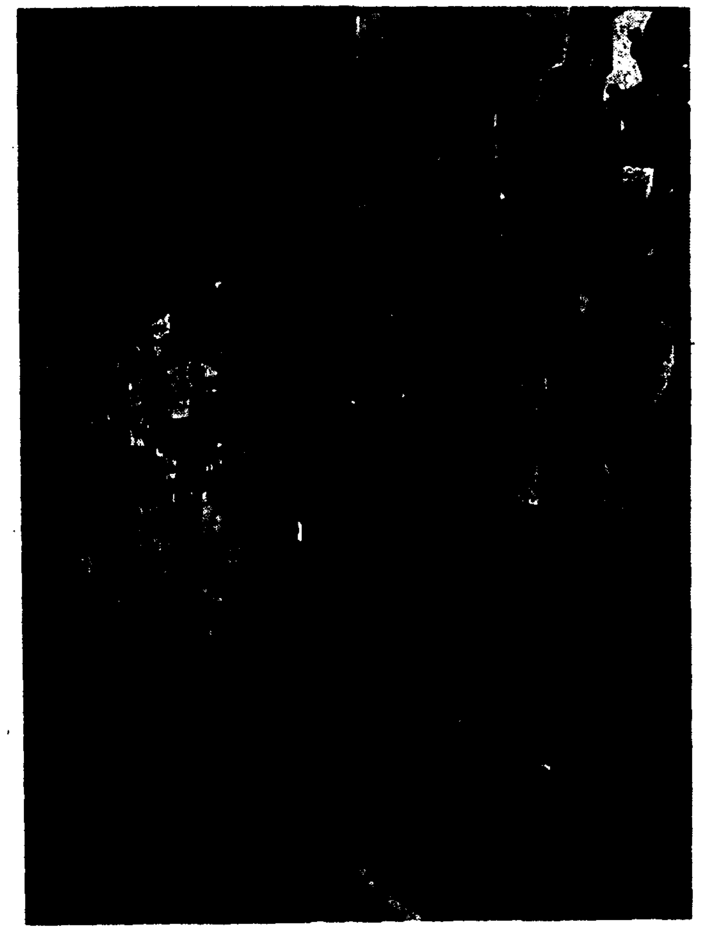
The site chosen for the new substation was formerly a poster bill store, which straddled the District Line station. In addition to the new electrical plant, the new building incorporates facilities for improved ventilation of the tube tunnels in the area, at a later date.

The District Line platforms and old substation, over which the new building has been erected, were never designed to take any substantial additional loads and their strengthening and adaptation posed several problems to London Transport engineers directed by Mr. C. E. Dunton, Chief Civil Engineer. The railway retaining walls, built in 1869, and part of the roof steelwork of the original substation had to be strengthened; a new girder, 65 feet long, spanning the platforms and tracks had to be placed, as the existing steel was inadequate; and additional underpinning steel was required beneath the stanchions carrying one of the girders of the "Exit" footbridge. The latter task was probably the trickiest of all, due to the very restricted headroom above the subway leading to the escalators of the southbound Northern Line.

However, as the plant with which the new substation is equipped is practically free from vibration and does not need massive foundations, as would be the case with heavy rotary converters, it has been possible to instal the new equipment on suspended floors.



Nos. 4 and 6 rectifier sets, with the transformer withdrawn from the right hand half-unit of No. 6 set.



52-year old D.C. traction switchgear in the old substation.

In the new building itself, the design of which was prepared by Mr. T. Bilbow, Architect to London Transport, the load carrying has been accomplished by placing new girders above the level of the foot-bridge walls, so that no loading of the new walls or roof is transmitted to the existing girders, and by using lightweight construction wherever possible.

Over the Rectifier Room, where the heaviest machinery is located, a clear roof span is essential and advantage was taken of this requirement to use a lightweight roof, consisting of light steel lattice beams carrying four aluminium monitor ventilators. The intermediate panels of the semi-flat roof are of aluminium decking, with lightweight waterproofing material as finish and a fireproof topping.

As the west wall of the Rectifier Room is clearly visible from Hungerford Bridge, the architectural aspect was considered carefully. In order to reduce weight, a light steel lattice framing was used, and clerestorey windows are provided at high level, with asbestos panelling below.

Apart from two large wall panels faced with pre-cast slabs finished in exposed shingle aggregate, the elevations to Embankment Gardens are faced with an Essex sand-faced brick. Other stone dressings are in reconstructed Portland stone. The whole effect is very pleasing and in keeping with the general surroundings.

Internally the walls have been left in fair-faced brickwork treated with emulsion paint, except in the staff rooms and Control Room where they have been plastered and painted.

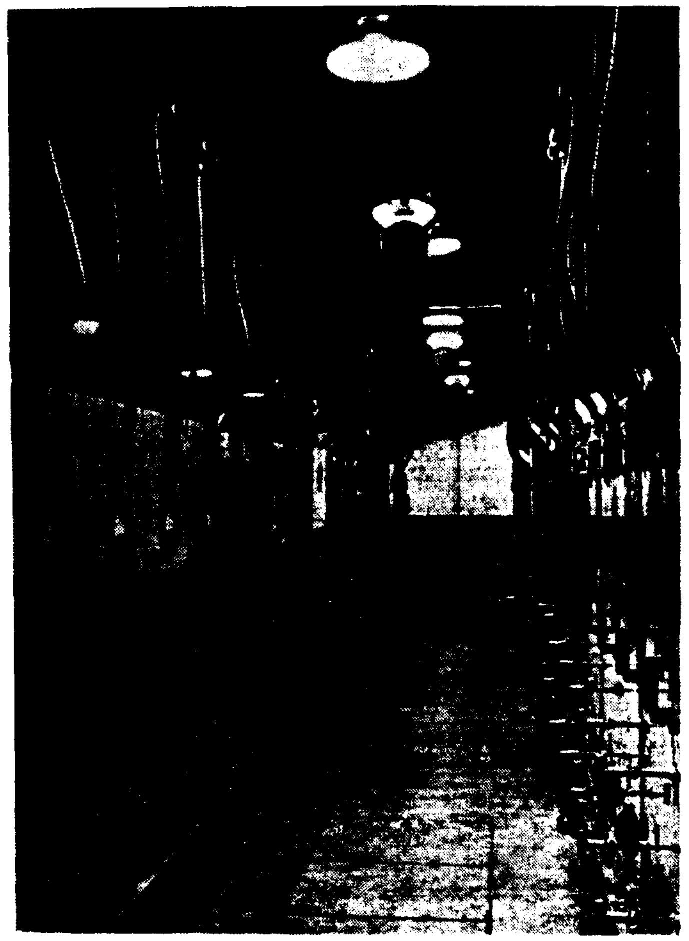
The west wall contains inlet louvres for cooling air to the adjacent transformer and rectifier sets. Cooling air for the sets situated in the centre of the Rectifier Room is drawn in through louvres at roof level by four 7,500 cu. ft./min axial flow fans, at Control Room floor level, and delivered through ducting to the area immediately behind these sets. Heated air leaves the building via the monitor vents in the roof.

SUBSTATION LAYOUT

The ground floor of the new building houses the rectifiers and transformers, together with the high voltage A. C. and the D. C. switchgear, while the rectifier relay panels, lighting and signal switch-gear, batteries, battery distribution switchboards and battery charging units have been installed on the upper floor. The Control Room, from which the power and signalling supplies for a large area will eventually be supervised, is also located on the upper floor. It will, however not be equipped for some time. Control of the new substation will be effected from new temporary panels situated in an adjacent room.

SUBSTATION EQUIPMENT

In general, the new equipment is similar to that installed at Bond Street in 1954 and, like Bond Street, its manufacture and installation have been carried out



Modern truck-type D. C. switchgear – positive at left and negative at right.

by the Hackbridge & Hewittic Electric Co. Ltd., to the requirements of Mr. T. S. Pick, Chief Electrical Engineer of London Transport.

(1) *Rectifiers*

The new substation is designed for an ultimate capacity of 12,000 kW, comprising eight rectifier sets each of 1,500 kW rating; however, only six sets are being installed in the first instance, a nominal 9,000 kW being considered adequate for the prevailing needs. These, of course, are capable of sustaining the short, heavy overloads normally called for with suburban railway equipments; they comply with Class III rating of BSS. 1698 : 1950.

A 1,500 kW set comprises a pair of 750 kW half-units, each with its own transformer and each employing 6-phase rectification. It is arranged, however, for the combined set to operate 12-phase; this is achieved by winding one transformer with a star primary, the other being connected in delta, so that the secondary phases of one are 30° out of phase with those of the other.

As at Bond Street, the transformers are closed-circuit air-blast cooled, thus eliminating the risk of fire. Each one is housed in a sheet steel enclosure, the air in which is continuously circulated through a heat exchanger which constitutes a form of tubular radiator with an external cooling fan. By this means the heat developed in the transformer is dissipated indirectly and no dust or dirt is drawn into its windings.

The rectifier bulbs are mounted above the transformer housings. The interphase transformers, fan control reactors and auxiliary transformers are located between the pair of main transformers forming a 12-phase set. It would have been impossible to get the required capacity of converting plant into the space available, without using this type of construction—a 1,500 kW set covering a floor area only nine feet square.

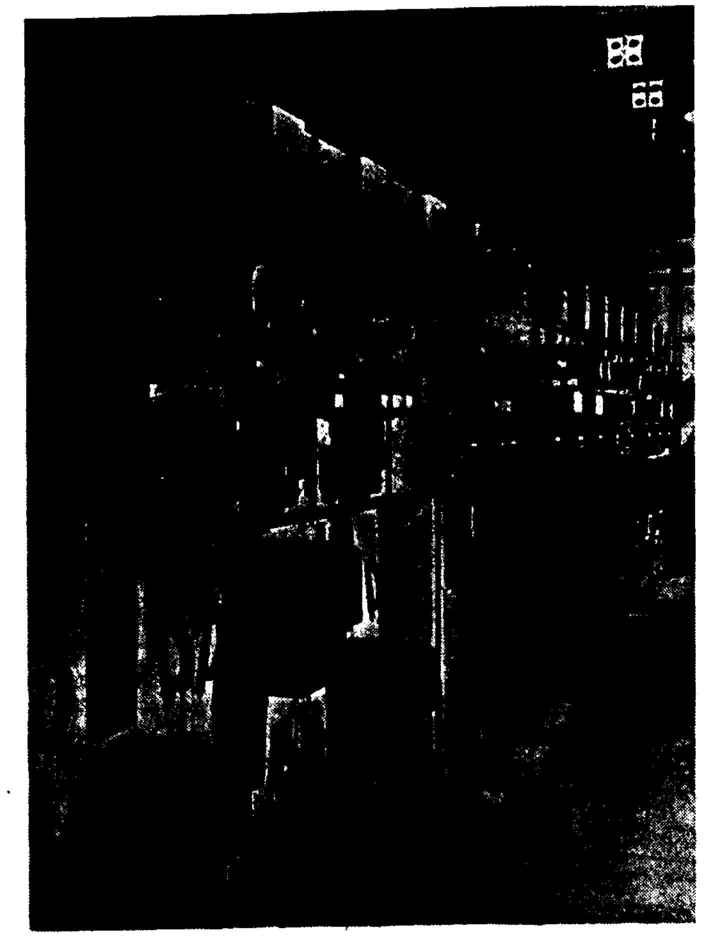
Linking facilities are provided so that one of a pair of half-units can be isolated, while attention is given to circulating fans or any other item, and the remaining half continues to give its 750 kW output, the rectification then being temporarily 6-phase. Removable gantries can be readily fitted to the cubicle framework for access to the bulbs and starter units.

(2) *Switchgear*

(a—High Voltage A. C.) The high voltage switchgear is by Switchgear & Cowans of Manchester, and comprises a bank of fourteen type FB. 31, vertical isolation, compound-filled units rated for 11,000 volts; these cater for three incoming feeders, seven rectifiers, two bus-section switches, one outgoing feeder, and one lighting transformer feeder. Space is available for an additional unit, if required. The switchboard is divided into three sections.

Solenoid closing is provided for all the circuit breakers, which are fitted with arc control devices and have a tested rupturing capacity of 350 MVA.

Protection on the incoming feeders is by Translay relays (instantaneous), as well as back-up protection, comprising inverse time overload and earth leakage relays. There is also frame earth leakage protection. Each incoming feeder has a voltmeter, ammeter and kWh-meter. The rectifier circuit breakers have over



The high voltage A.C. switchgear.

current and earth fault protection and means for remote load indication.

Modernisation of this substation has entailed the provision of three new 11 kV 0.25 sq. in. 3-core, paper insulated, lead alloy sheathed feeder cables from Aldgate to Charing Cross via the District Line tunnels, together with a pilot cable for Translay protection purposes. These cables were supplied by W. T. Glover & Co., and installed by London Transport staff.

(b—D. C. Traction) The D. C. 630 volt switchgear is in two banks, the positive circuit breakers in one and the corresponding negative contactors in the other. The two banks face each other, and the sequence of the units is so arranged that the positive circuit breaker faces its corresponding negative contactor. This equipment is made by Bertram Thomas (Engineers) Ltd. of Manchester, and comprises truck-type drawout units. There are 25 cells in each bank but two are skeleton units and will be equipped if and when the other two rectifier sets are installed. One pair of these cells contains emergency trucks for use as temporary replacements in case of a fault in, or damage to, the equipment of any other track feeder unit. The rating of the circuit breaker and contactor on these standby trucks is 3,000 amps.

Both the circuit breakers and the contactors are electrically closed, the former being of the high-speed type. Those for the rectifiers are rated at 4,000 amps. while the outgoing feeders are 3,000 amps. The former trip only on reverse current—which would result from a fault in the associated rectifiers—and the tripping of any one of these opens the associated highvoltage A. C. breaker. The feeder circuit breakers do not reclose automatically after tripping on a fault or overload, but give an alarm at the controlling point; the operator then restores the supply at his discretion. The circuit breakers are closed by push-button control and latch in, the negative contactor following automatically. Similarly, on opening, the contactors follow the breakers, since their closing and holding circuits are completed via auxiliary contacts on the circuit breaker.

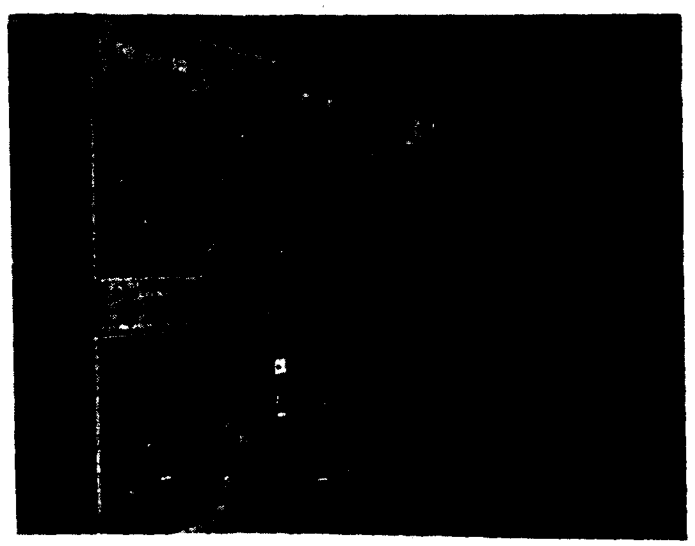
Two pairs of couplers of 4,000 amp. rating divide these twin switchboards into three sections, and in the first instance two rectifier sets will feed into each section. Sections 1 and 3, however, have additional skeleton housings for the future rectifier units referred to previously. Section 1 has feeder circuit breakers supplying two northbound and two southbound sections of the Northern Line and section 2 supplies four similar lengths of track on the Bakerloo Line. The east and westbound tracks of the District/Inner Circle Lines are supplied from section 3.

Section 1 also gives a feed to the lifts and escalators on the Northern Line, while sections 2 and 3 give similar feeds to a small bank of enclosed switchgear standing adjacent to the end of the negative contactor bank. This switchgear also is by Bertram Thomas but, in this case, the circuit breakers are of the semi-high speed type, single pole, with accompanying negative contactors. There are two separate lengths of 630 volt busbar; one supplies lifts and escalators on the Bakerloo Line, while the other feeds pumps and escalators on the District Line.

Each section of the main D. C. switchboard has its own voltmeter, mounted over the central gangway between the two banks, and each length of positive and negative busbar has surge arresters for discharging to earth any surge voltages that may develop on the system. These have fuses capable of breaking the "follow-through" current should the arrester fail. An isolating switch ensures safety when replacing a fuse.

Finally, each negative busbar has an earth fault relay. As both poles of the system are normally fully insulated, any considerable current leakage from the positive pole will lead to an increase in potential between the negative pole and earth. If this is of sufficient magnitude, the relay will operate and give warning that a fault has developed. This facility assists in locating faulty trains.

Test panel equipment for the positive and negative D. C. trucks is mounted on the side wall of the building in a convenient position. *(c – Low Voltage, A.C.).* For the time being, a low voltage A.C. supply for station lighting and auxiliary purposes is obtained from an existing group of three single-phase transformers in the old substation at 220 volts, 33⅓ cycles, but later the system is to be standardised at 415 volts, 50 cycles, four wire and fed from a transformer to be installed in the new building. The new switchboard is designed for the future conditions, although operating temporarily on the existing system; it is located on the upper floor and incorporates six double-tier units of the draw-out type manufactured by Switchgear & Cowans. The incoming circuit breaker is rated at 1,200 amps. and the feeder circuit breakers at 400 amps.; they are of the air-break type and supply the Signal Engineer's distribution mains. A system of couplers and isolators



220V lighting switchboard, rectifier relay board and (extreme right) main marshalling cabinet.

is included in the switchboard, so that any of these vital lighting feeders can be fed from an adjacent circuit, should its own circuit breaker require attention, or for convenience of maintenance.

The remainder of the switchboard consists of fuse-switches for air compressors, main ventilating fans, a signals transformer, substation lighting, heating and battery chargers, and future additional services.

Facing this switchboard is the signal switchboard, which is in two sections; one portion operates at 600 volts, single phase, and is fed from a transformer in the old substation for supplies to District and Bakerloo Lines; the other gives a 440 volt supply for the Northern Line and for tunnel telephones.

The frequency of the supply to all signalling equipment will be maintained at 33⅓ cycles after the main conversion to 50 cycles; this is to prevent inadvertent operation of signals by possible fault current from any 50 cycles power supply system. The retention of the 33⅓ cycles supply will necessitate the installation of motor generators or some other form of frequency-changer at a later date.

(3) Auxiliary Equipment

Much of the auxiliary equipment, including the 50 volt and 110 volt battery chargers and distribution switchboards, is also installed on the upper floor. Batteries are located in a separate room together with the Signal Engineer's telephone batteries.

(4) Cables

The track feeder, escalator, lighting and pump feeder cables, which are the responsibility of the Signal Engineer, are being lengthened and re-routed to the new substation; the new cabling being paper insulated, lead covered of the pre-impregnated, non-bleeding type. Track feeder cables are 1.4 sq. in. single-core, escalator cables 0.4 sq. in. concentric, while the lighting cables are 3-core 0.25 sq. in. shaped conductor cables; lead alloy sheathing is to alloy 'C' BSS. 1938. A mechanical sealing end, developed by the Signal Engineer, is being used for terminating the track end of each track feeder cable.

Due to limited clearances, the existing cable runs are being used and modernised where necessary. The cables were manufactured by W. T. Glover & Co. Ltd. and installed by London Transport.

(Continued on page 72)

STEAM, DIESEL AND ELECTRIC LOCOMOTIVES SUPPLEMENT

CONTENTS

The Development of High-Speed MERCEDES-BENZ Diesel Engines for Diesel train traction

By Dr. Ekhart Schmidt,
Stuttgart-Unterturkheim

THE development of high-speed diesel engines, in particular, of those with a high output, for powering diesel trains was greatly encouraged by the Deutsche Reichsbahn (German State Railways) which planned, designed and operated diesel railcars over 25 years ago. The Deutsche Bundesbahn (German Federal Railways), the successor in the Federal Republic of Germany to the Deutsche Reichsbahn, has resumed this tradition after the war and is pursuing it with great vigour, in particular, as far as main line traffic is concerned. New diesel railcars—express railcars and diesel locomotives—which have been developed (1, 2, 3) are playing an increasingly important part in long-distance traffic in the Federal

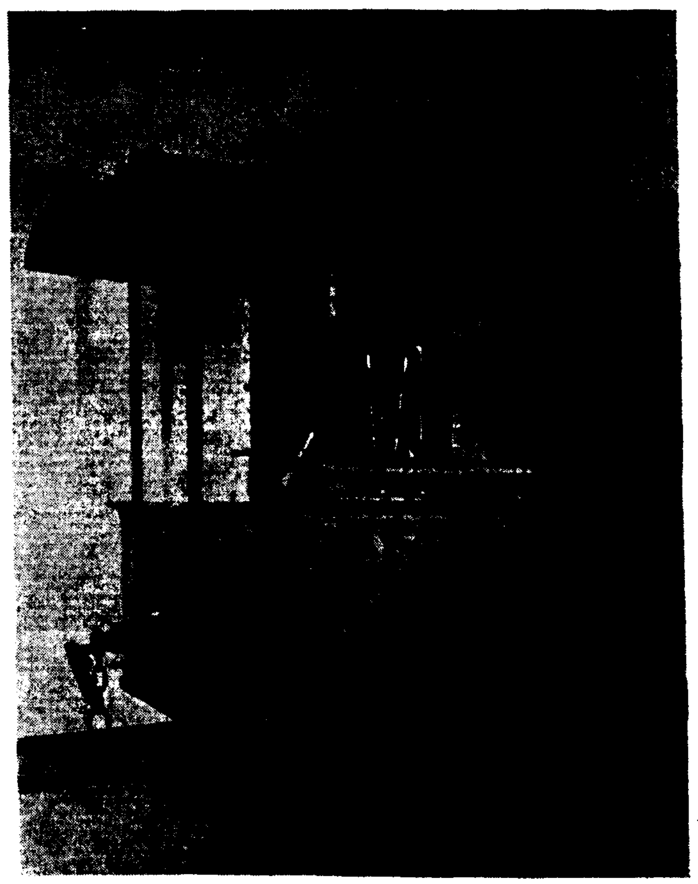


Fig. 1. Engine-powered locomotive of the Daimler-Motoren-Gesellschaft, made in 1887, Ne=5.5 PS, n=620 r.p.m.

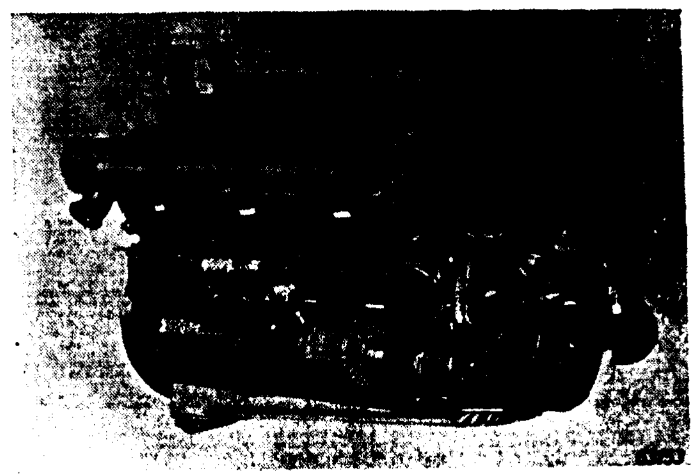


Fig. 2. MERCEDES-BENZ 12 cylinder Diesel engine MB 805, built in 1932, Ne=300 PS, n=1,500 r.p.m.

Fig. 3. MERCEDES-BENZ 12 cylinder Diesel engine MB 807, built in 1936, Ne=275 PS, n=1,500 r.p.m.

1) Lampe, Curt und Pflug, Erhard:
Die 1000-PS-Diesellokomotive der Deutschen Bundesbahn fur leichten Strecken—und schweren Rangierdienst. - Glas. Ann. (1952) Nr. 4 S. 72/86

2) Lampe, Curt und Goessl, Nikolaus:
Die 2000-PS-Diesellokomotive der Deutschen Bundesbahn. ETR 2 (1953), Nr. 6/7, S. 275/289

3) Lampe, Curt:
Grundzuge der Diesellokomotive-entwicklung bei der Deutschen Bundesbahn. MTZ 14 (1953), Nr. 8, S. 223/225

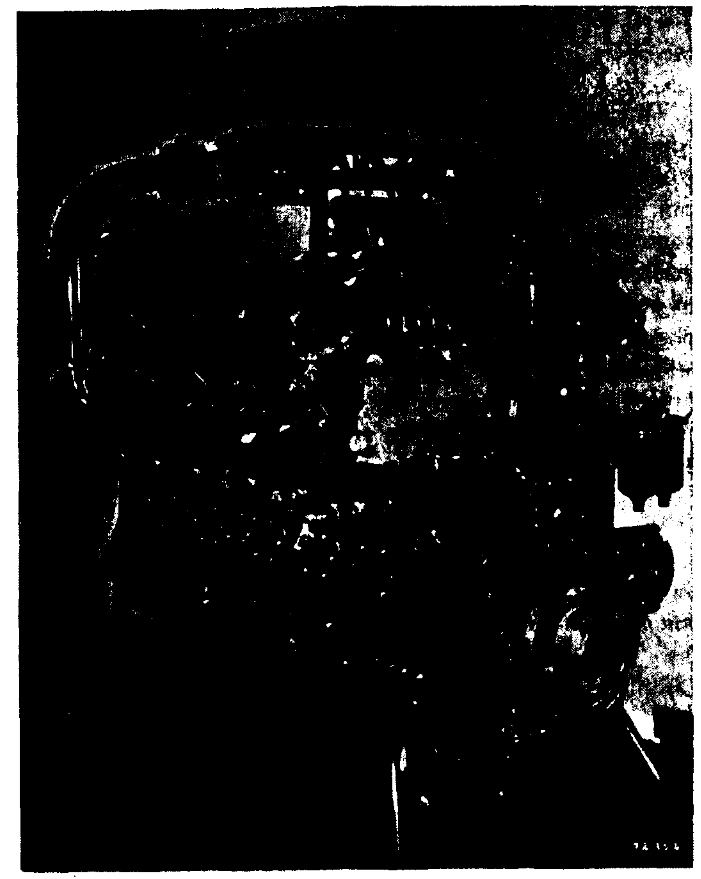


Fig. 4. MERCEDES-BENZ 12 cylinder Diesel engine MB. 816, with BBC exhaust gas turbo-charger, built in 1938, Ne=650 PS, n=1,400 r.p.m.

Fig. 5. Express railcar of the Belgian State Railways, equipped with 2 MERCEDES-BENZ Diesel engines MB 806 each of which has an output of 450 PS, maximum speed 93 to 100 m.p.h.

Republic and are frequently installed in trains which run to the capitals of neighbouring countries.

Fig. 6. Bogie of a Diesel railcar with diesel-electric transmission with MERCEDES-BENZ Diesel engine MB 806, built in 1936, Ne = 450 PS, n = 1,400 r.p.m.

Side by side with this development, the use of high-speed diesel engines for shunting operations is constantly gaining ground not only on account of the great economy of operation of the diesel engine which is undisputed in this special field but also because of the advantages of the high-speed engine as such.

Ever more powerful units, larger by far than those which are increasingly being used for diesel rail buses, are being built into railcars which operate on branch lines. These have a higher haulage capacity and can be operated with trailcars, as well as with goods wagons, etc. as the case may be.

The reasons for the use of high-speed engines must be sought in the fact that they are extremely suitable

Fig. 7. MERCEDES-BENZ 12 cylinder diesel engine MB 820 Bb with BBC exhaust gas turbo-charger, Ne = 1,100 PS, n = 1,500 r.p.m.

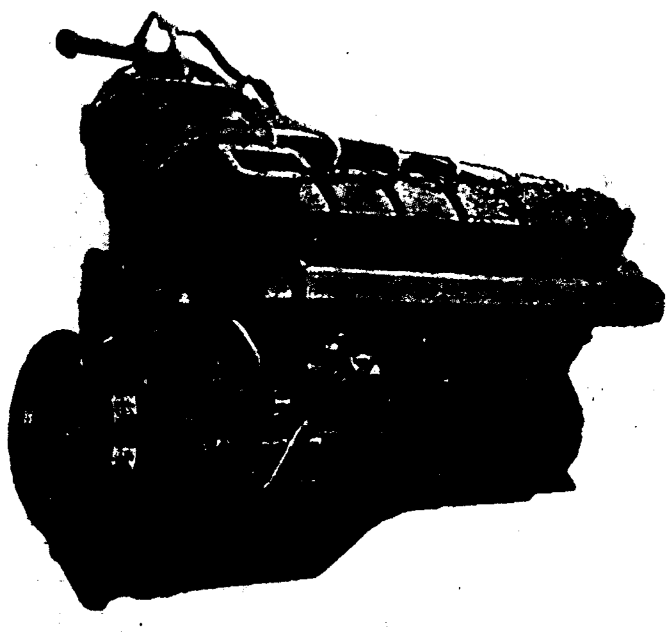


Fig. 8. MERCEDES-BENZ 6 cylinder diesel engine MB 836 Bb with BBC exhaust gas turbo-charger. Ne = 500 PS, n = 1,500 r.p.m.

for installation in rail-bound vehicles. Since they have smaller dimensions and a lower structural weight, possibilities are opened up which are non-existent with the much heavier low-speed engines. Thus the installation of engines in the bogie, e. g. of Diesel railcars, is limited to sizes and weights which preclude the use of engines with low revolution speed. For this reason the development of express railcars for long-distance traffic which was sponsored by the German State Railways and the German Federal Railways could not have been effected if light, high-speed Diesel engines had not been available, and my later remarks will show that it has recently proved possible to install such engine units with an output of 1100 PS and more in the bogie. There are prospects of increasing these output figures still further. Because they save space and weight, the high-speed engines offer a great many advantages for installation in Diesel locomotives. Thus the number of axles is determined by the permissible load per axle and the use of light and small engines makes it possible to limit the number of axles, which in turn results in the use of cheaper locomotives designs, indeed, in many cases it makes it at all possible to operate at certain output ranges although the bearing capacity of the superstructure is limited. Obviously, these remarks are only valid within the limits set by the adhesion weight of the locomotives required for the trailer load.

The advantages of using smaller and lighter, that is to say, high-speed engines not only lie in the field of diesel vehicle design but also to a very large extent in the operational and economical range.

The fact that those parts in the installed engine which require servicing can be quickly dismounted, whilst their weight remains slight, and that the engines can be easily exchanged for the routine overhauls, contributes considerably to economical operation inasmuch as the time during which the vehicles are out of operation so that work can be done at the engine plant can be considerably cut down or eliminated altogether. Minor maintenance jobs only require little time whilst more important jobs are not carried out in the vehicle since the light engine can be dismounted very quickly indeed and replaced by an exchange unit.

Like other German firms, *Daimler-Benz* has played an important part in the development of high-speed engines for rail-bound vehicles. At the birthplace of the first high-speed combustion engine of the Daimler-Motorengesellschaft which has been designed by Gottlieb Daimler in 1883, the first rail-bound vehicles of the world to be equipped with combustion engines, among them the first engine-driven locomotive (Fig. 1) were built as early as 1887.

Before the last war, high-speed engines ranging from 35 to 650 PS, make *Daimler-Benz*, were available for Diesel train traction. Below, we shall only deal with engines with a higher output—from 275 to 650

Fig. 9. MERCEDES-BENZ 12 cylinder diesel engine MB 820 Db with high-supercharging by a BBC exhaust gas turbo-charger and intercooling, Ne = 1,350 PS, n = 1,500 r.p.m.

PS at 1,500 r. p. m.—which have undergone further development culminating in the new types which, as already mentioned, have outputs of 1100 PS at the same engine speed.

In the output range between 275 and 650 PS, three engine types were increasingly being used by the Deutsche Reichsbahn before the war:

1. The engine MB 805, 12 cylinders, in V-arrangement, 138 mm. (5 7/16 in.) bore, 170 mm. (6 11/16 in.) stroke, $V_H = 30.5$ l, not supercharged, with an output of $N_e = 300$ PS at n = 1,500 r. p. m. (Fig. 2).
2. Engine MB 807, 12-cylinder, opposed cylinder arrangement, with the same dimensions as engine MB 805, not supercharged, with an output of $N_e = 275$ PS at n = 1,500 r. p. m. (Fig. 3).
3. Engine MB 806, 12 cylinders in V-arrangement, 165 mm. (6½ in.) bore, 195 mm. (7 11/16 in.) stroke, $V_H = 50.0$ l, not supercharged with an output of $N_e = 450$ PS at n = 1,400 r. p. m.

   supercharged by a BBC exhaust gas turbo-charger as MB 816 with an output of $N_e = 650$ PS at n = 1,400 r. p. m. (Fig. 4).

The engine output was transmitted mechanically, electrically, hydraulically or hydraulic-mechanically as the case may be, whereby equally good results were achieved with the diesel-electric and diesel-hydraulic

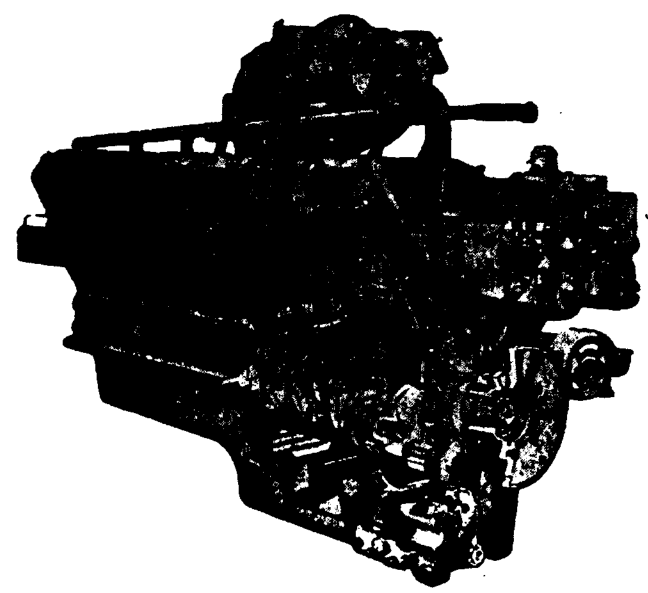


Fig. 10. MERCEDES-BENZ Diesel engine MB 820 Bb – sectional view.

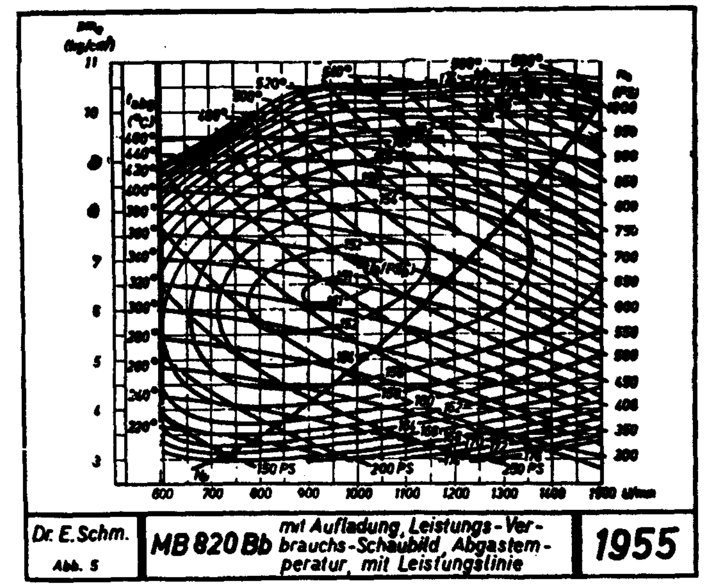


Fig. 11. MB 820 Bb with BBC exhaust gas turbo-charger, Ne = 1,000 PS, n = 1,500 r.p.m., output consumption diagram, exhaust gas temperature, with output curve for diesel-hydraulic drive.

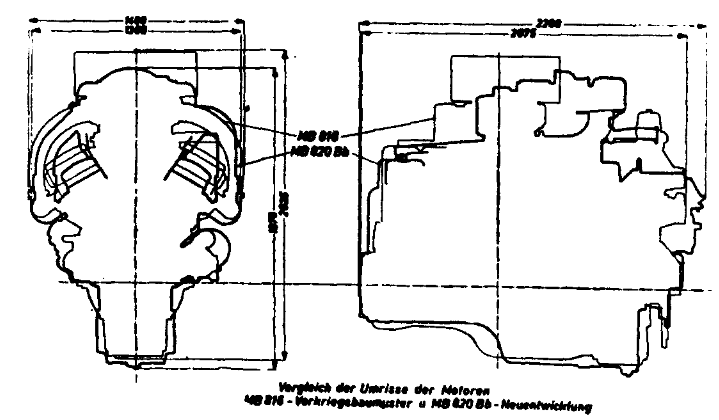


Fig. 12. Comparison of the basic designs of engines MB 816 (pre-war type) and MB 820 Bb (new design).

types of power transmission. The hydraulic or hydraulic-mechanical system of transmission determined the entire post-war development of diesel train traction by the Deutsche Bundesbahn.

The following figures show examples of installation of the engine types aforementioned:

Fig. 5: Express railcars of the Belgium State Railways equipped with two *Mercedes-Benz* diesel engines of type MB 806, each of which renders an output of 450 PS, maximum speed 93 to 100 m. p. h. Fig. 6: Engine MB 806, installed in the bogie of an express railcar with diesel-electric power transmission.

The demands which must be kept in mind when designing high-speed diesel engines for rail-bound vehicles are resistance to very hard operating conditions, in particular in view of the many extreme load and engine speed changes involved, on the one hand, and high resistance to wear and long service life of all those engine parts which, if they have to be overhauled, make it necessary to dismount the engine, namely the bearings, and the cylinder bushings and pistons, on the other hand. Such demands are not easily met and they required considerable and very detailed development work. Nevertheless, it was

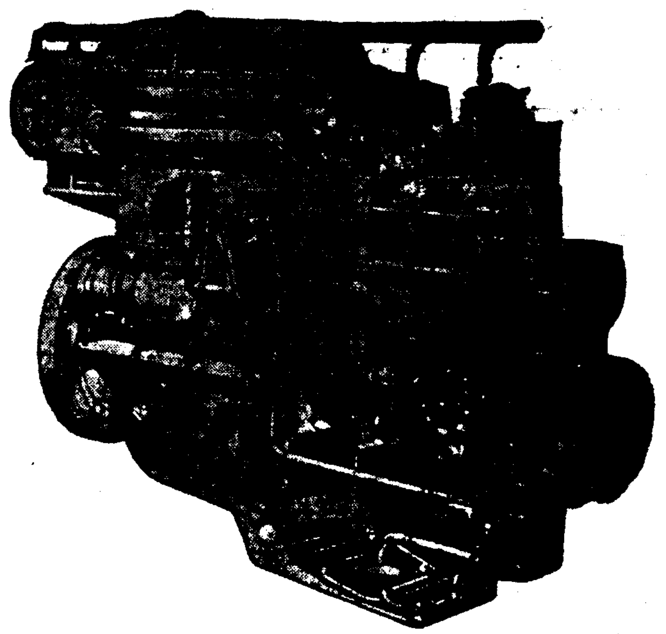


Fig. 13. MERCEDES-BENZ diesel engine MB 846 Ab-sectional view.

Fig. 14. MERCEDES-BENZ 6 cylinder underfloor Diesel engine MB 846 Bb, Ne = 300 PS, n = 1,500 r. p. m.

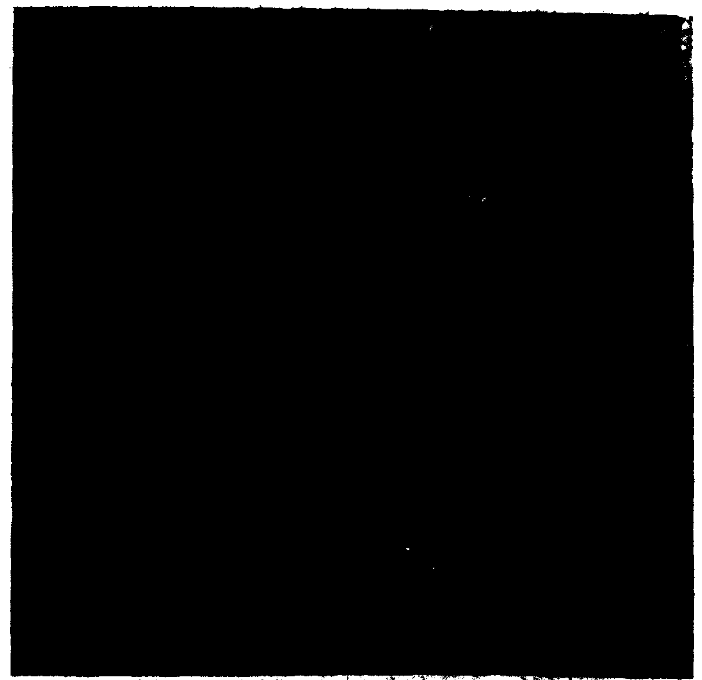


Fig. 15. The carriage body is lowered on the bogies of a Diesel railcar equipped with a MERCEDES-BENZ diesel engine MB 820 Bb, Ne = 1,000 PS, n = 1,500 r. p. m.

possible already before the war to reach service figures of 4,000 operational hours with engine MB 806 under very hard operational conditions, e. g. in express traffic in the Ruhr area, before dismounting the engine for an overhaul.

After the war considerably higher performance standards were set from the very beginning for the express railcars and Diesel locomotives which had been newly developed by the Deutsche Bundesbahn. For the railcars VT 08[2]) and the Diesel locomotives V 80[1]) this was at first 800 PS per engine, a figure which was soon raised to 1,000 PS whilst two engines with 1,000 PS were at first installed in the Diesel locomotive V 200[3]) the output of which has recently been raised to 1,100 PS. These demands for higher performance per unit would have led to new engine developments after the war even if it would have been possible to resume manufacture of the pre-war engines. The work of development which was then carried out naturally utilised the fund of experience accumulated both before and during the war with the construction and operation of light, high-speed Diesel engines. *Daimler-Benz* brought out two new engine types with the designation MB 820 (Fig. 7) and MB 836 (Fig. 8), one of which is a 12-cylinder engine whilst the other has 6 cylinders, both of them, however, have the same stroke and

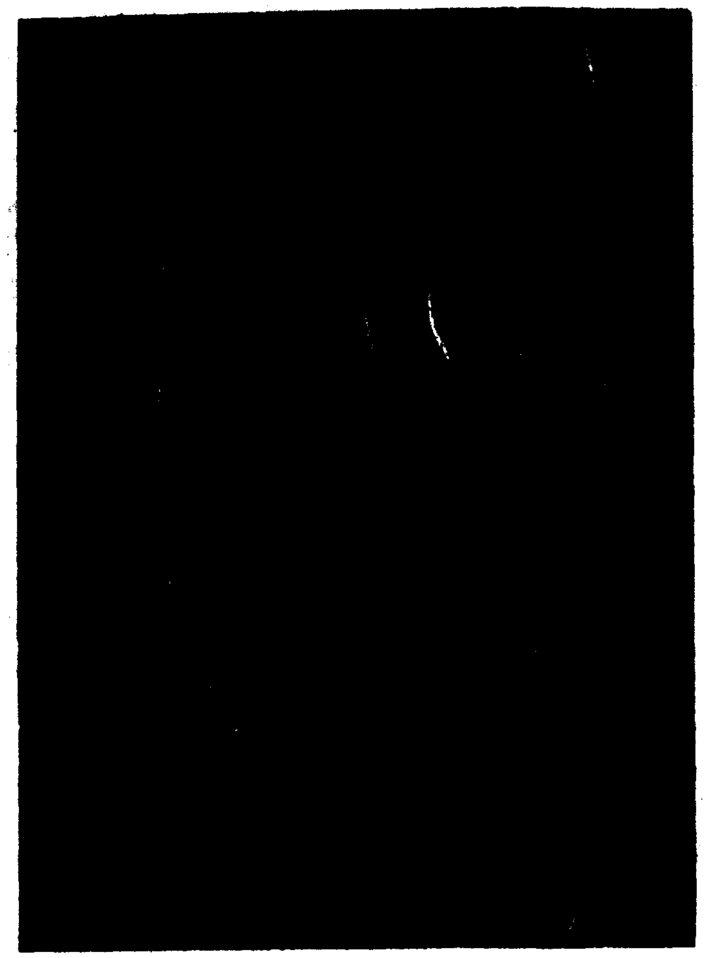


Fig. 16. Engine compartment of the diesel locomotive V 200 of the Deutsche Bundesbahn equipped with 2 MERCEDES-BENZ diesel engines MB 820 Bb, Ne = 1,100 PS, n = 1,500 r. p. m.

bore and many of their components, such as piston rods, cylinder bushings, pistons, cylinder heads, all control parts, injection pumps and nozzles, to name but a few, are also the same, in other words, nearly all parts which have to be overhauled and, possibly, exchanged. This provides considerable advantages with regard to stocks of spare parts, reconditioning, training of personnel, etc. if both types are operated by the same railway company, as they are by the Deutsche Bundesbahn. Both types have been built in a non-supercharged and in a supercharged design, in which case BBC exhaust gas turbo-chargers were used, to the following specifications:

	MB 820	MB 836
Stroke	205 mm.	205 mm. (8 5/64 in.)
Bore	175 mm.	175 mm. (6 57/64 in.)
No. of cylinders	12	6
Cylinder arrangement	V	in line
Engine speed n	r. p. m. 1,500	1,500
Type designation of the engine, not supercharged	MB 820 B	MB 836 B
Output when n = l = 1,500 r. p. m.	PS 700	350
Type designation of supercharged engine	MB 820 Bb	MB 836 Bb
Output when n = 1,500 r. p. m.	PS 1100	500

Both types are also built with intercooling—type designation MB 820 Db and MB 836 Db respectively (Fig. 9) —a design which is mainly used for ship propulsion units, but also for railways operating under tropical conditions and, under certain circumstances, in order to raise the output. The output available in each case depends on the prevailing atmospheric conditions (temperature, humidity) and on the circumstances governing installation (e. g. possible size of cooling unit).

We do not propose to go into the technical design of engines MB 820 and MB 836 and of the pre-war types in detail. We refer the reader to earlier publications (4., 5.). We shall only select a few essential points using the sectional view of engine MB 820 Bb (Fig. 10) to make ourselves clear, and compare them with the earlier types.

The crankcase of the new engine type is made of heat-treated silumin like the earlier one, but that of the newer design is drawn up to the upper edge of the cylinder and thus very rigid, special cylinder blocks of cast iron—in each case jointly for three cylinders—were separately placed on the crankcase of the earlier types. Cylinder liners of special alloys are

4) Buschmann, Heinrich: Triebwagenmotoren. MTZ 1 (1940), Nr. 5, S. 139/152. MTZ 1 (1940), Nr. 6, S. 209/212.

5) Schilling, Otto: Der neue 800-PS-Daimler-Benz-Triebwagen-Dieselmotor mit mechanisch angetriebenem Lader oder Auspuff-aufladung. MTZ 11 (1950), Nr. 4, S. 93/96.

Fig. 17. A MERCEDES-BENZ diesel engine MB 820 B without supercharging, Ne = 700, n = 1,500 r. p. m. being mounted in a shunting locomotive of Messrs. Krauss-Maffei A. G., Munich.

mounted in these cylinder blocks and, in the new types, in the crankcase, these liners are specially adapted to the light-metal pistons and piston rings used in all types. In the new types, the upper piston ring is chrome-plated in order to further reduce wear. The crankshaft has heat-treated journals, case hardened or induction hardened, and runs on steel-backed lead bronze bearings. The design of the bearings is in principle the same as in the earlier types, except that lead bronze has also been further improved and a surface layer of lead with a thickness of 0.02 to 0.03 mm. has been laid on the lead bronze—in the new designs—which advantageously effects the running properties.

The piston rods in the 12-cylinder engines MB 820 and MB 806 have a different design. Whereas the main connecting rod of the pre-war engine MB 806 was of the forked type with an auxiliary rod oscillating on the bearing shell on the outer side, in engine MB 820 the piston rods of two opposite cylinders lie next to each other on the same crankpin, a design which permits the use of the same connecting rods for all 12 cylinders.

Special care has been expended on the new types to ensure that the time required for overhauling and checking those parts of a built-in engine which have to be serviced is kept as low as possible, for this reason single cylinder heads have been provided as against the joint cylinder heads for 3 cylinders which were the rule in the pre-war types. This is the only way to cut down on the time required for the maintenance of a built-in engine, since no lifting appliances of any kind are required to remove the single cylinder heads made of special cast iron. The heads are directly accessible and can be lifted up, after the nuts of the cylinder head bolts have been loosened, without dismounting the intake and exhaust lines. This is further facilitated by the fact that the valves are actuated by push rods as they were in the pre-war engines too. In the cylinder head, there are 2 intake and exhaust valves each around the pre-chamber which lies in the center.

Both engine MB 816, which is a pre-war type, and the new engine types are charged by BBC exhaust gas turbo-chargers.

In engine MB 816, one supercharging unit with vertical axis was over the V, it was not cooled. In

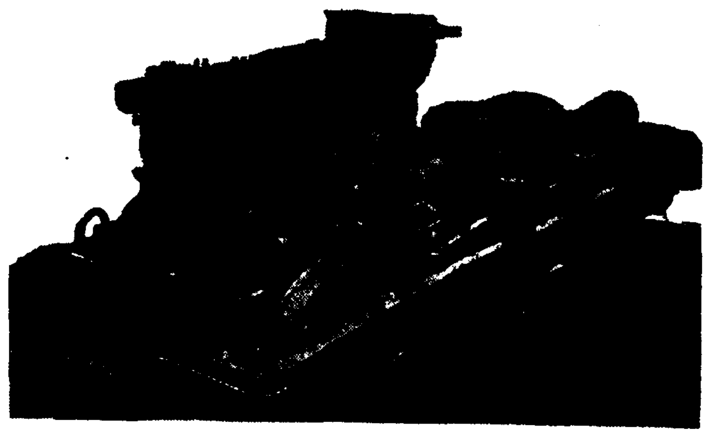


Fig. 18. Bogie of a diesel railcar with MERCEDES-BENZ diesel engine MB 836 Bb, Ne = 500 PS, n = 1,500 r. p. m.

Fig. 19. Shunting locomotive of Messrs. Krauss-Maffei A.G., Munich, equipped with a MERCEDES-BENZ diesel engine MB 836 Bb, Ne = 500 PS, n = 1,500 r. p. m.

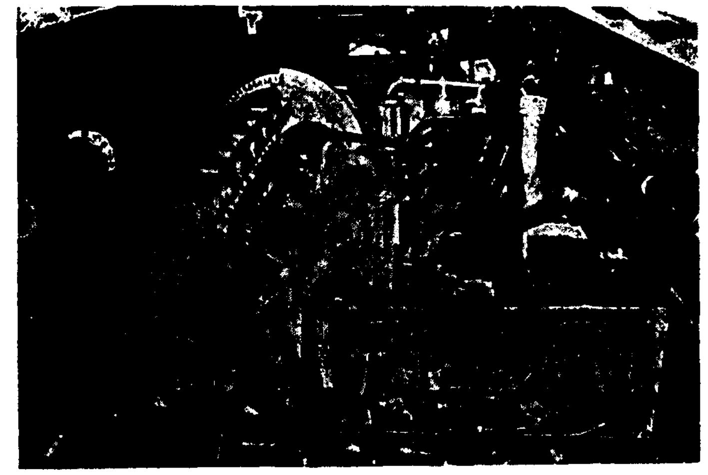


Fig. 20. Installation of MERCEDES-BENZ underfloor diesel engine MB 846 Bb, Ne = 300 PS, n = 1,500 r. p. m. in a railcar " DGT 600 ".

engines MB 820 and MB 836 water-cooled supercharging units with horizontal axis are used. In engine MB 820 Bb the unit is located over the V, in engine MB 836 Bb at the end of the line of cylinders. The engine MB 820 Db which has intercooling and high supercharging has 2 supercharging units one behind the other in the V, whereas the intercooler is so arranged over the lines of cylinders that it does not impede the dismounting of the cylinder heads.

Special care has been expended on the design of the parts of the cumbustion chamber as well as of the injection system. All engines work according to the four-stroke principle. The combustion chamber greatly differs from the pre-war types, although the pre-chamber system has been retained and has thus undergone considerable further development.

Fig. 11 shows the output consumption diagram of engine MB 820 Bb in its previous design for N_e = 1,000 PS at n = 1,500 r. p. m. without intercooling and with normal supercharging. It will be seen that the minimum consumption approximates to 150 g/PSh and lies under 160 g/PSH for a wide range. The output curve according to which the engine is operated with the hydraulic drive of the vehicles of the Deutsche Bundesbahn has also been traced in the diagram.

In the meantime, the output of engine MB 820 Bb without intercooling has been raised to 1,000 PS at 1,500 r. p. m. thanks to improvements in the exhaust gas turbo-chargers and injection system. At the same time, it has proved possible to reduce both the consumption at 1,100 PS and the exhaust gas temperature below the level which was previously reached with the 1,000 PS engines.

It is interesting to compare the two engines MB 806/816 with the engines MB 820 B/MB 820 Bb in respect of specific output, space requirements and weight, since this clearly illustrates the considerable improvements which have resulted from further development work on the high-speed Diesel engine. Fig. 12 compares the basic designs of the two supercharged engines MB 816 and MB 820 Bb.

		MB 806	MB 820 B
Length	mm	2125 ($83\frac{21}{32}$ in.)	2200 ($86\frac{5}{8}$ in.)
Height	mm	1685 ($66\frac{5}{16}$ in.)	1540 ($60\frac{5}{8}$ in.)
Width	mm	1410 ($55\frac{1}{2}$ in.)	1300 ($51\frac{1}{4}$ in.)
V_H	l	50.0	59.2
Weight	kg	2500 (5,500 lbs.)	2450 (5,390 lbs.)
Output	PS	450	700
n	r.p.m.	1400	1500
p_e	kg/cm²	5.8 (82 psi)	7.1 (100 psi)
Power-weight ratio	kg/PS	5–55	3.5

		MB 816	MB 820 Bb
Length	mm	2075 ($81\frac{11}{16}$ in.)	2200 ($86\frac{5}{8}$ in.)
Height	mm	2025 ($78\frac{3}{4}$ in.)	1970 ($77\frac{9}{16}$ in.)
Width	mm	1400 ($55\frac{1}{8}$ in.)	1360 ($53\frac{17}{32}$ in.)
V_H	l	50.0	59.2
Weight	kg.	2820 (6,200 lbs.)	2800 (6,160 lbs.)
Output	PS	650	1100
n	r.p.m.	1400	1500
p_e	kg/cm	8.35 (119 psi)	11.2 (171 psi)
Power-weight ratio	kg/PS	4.35	2.55

From Fig. 12 and the table above it can be seen, that whilst the pre-war type and the newly-developed designs have approximately the same space requirements, the output of the non-supercharged engine has been raised by 55% whilst that of the supercharged one has undergone an increase of 70%, besides increasing the engine speed from 1,400 to 1,500 r. p. m. the mean effective pressure was raised by a third. It has proved possible to reduce the power-weight ratio quite considerably: from 5.555 to 3.5 kg/PS in the non-supercharged and from 4.35 to 2.55 kg/PS in the supercharged engine.

The two above-mentioned types MB 820 and MB 836 were supplemented by another type, namely engine MB 846, a 6-cylinder in-line engine with a total piston displacement of 20l, a bore of 150 mm. and a stroke of 190 mm. This engine is manufactured both as a vertical engine—Fig. 13—and as a horizontal engine—Fig. 14. It renders an output of 225 PS at 1,500 r. p. m. when supercharged, and further efforts are being made to improve both out put and engine speed.

The engine has the same basic design as type MB 836. The crankcase—in this case of cast iron—is also drawn up to the edge of the cylinder. This engine too, has inserted wet cylinder bushings of special cast iron, light metal pistons with top chrome-plated piston ring, and a crankshaft with induction-hardened crankpins running on lead bronze bearings. The single-cylinder heads have only one exhaust and intake valve each, which means that the pre-chamber has been slightly shifted away from the center of the cylinder. The exhaust gas turbo-charger lies at the end of the cylinder line as in the MB 836.

The above-mentioned three new types of engines MB 820, MB 836 and MB 846 have been extensively used in the most various kinds of railway drive units. Engine MB 820 Bb has been mainly installed in the express railcar VT 08 and in the Diesel locomotives V 80 and V 200 of the Deutsche Bundesbahn. Fig. 15 shows a carriage body being lowered onto the bogies of railcar VT 08, Fig. 16 shows the engine compartment of the Diesel locomotive V 200 with the same engine. The non-supercharged engine MB 820 B is used for shunting locomotives. Fig. 17 shows a locomotive which is built by the firm of *Krauss-Maffei A. G.*, Munich, in process of being assembled. The low design of the non-supercharged engine results in excellent visibility in the completed locomotive. Moreover, when certain types of power transmission are used, e. g. with a mechanical type of power transmission, the characteristics of the non-super-charged engine are unusually advantageous.

Engine MB 836 is used for railcars with an output up to 500 PS both by the Bundesbahn and by other railway companies as well as being installed in shunting locomotives to an increasing extent. As examples of the type of installation involved, we should like to call the reader's attention to the bogie

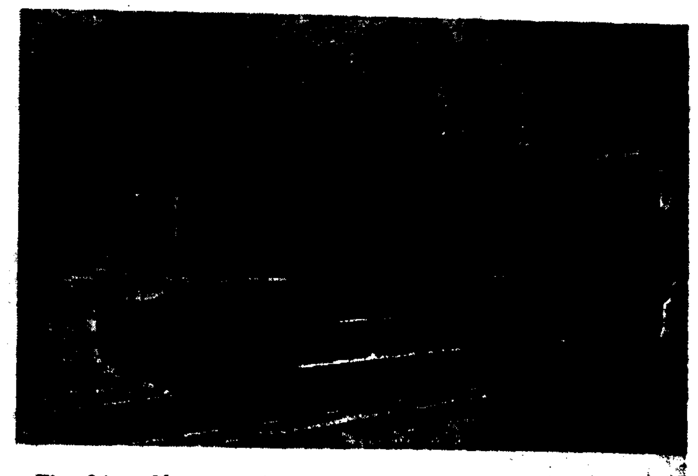


Fig. 21. Shunting locomotive of Messrs. Fried. Krupp, Essen, equipped with a MERCEDES-BENZ diesel engine MB 846 A, Ne = 225 PS, n = 1,500 r.p.m.

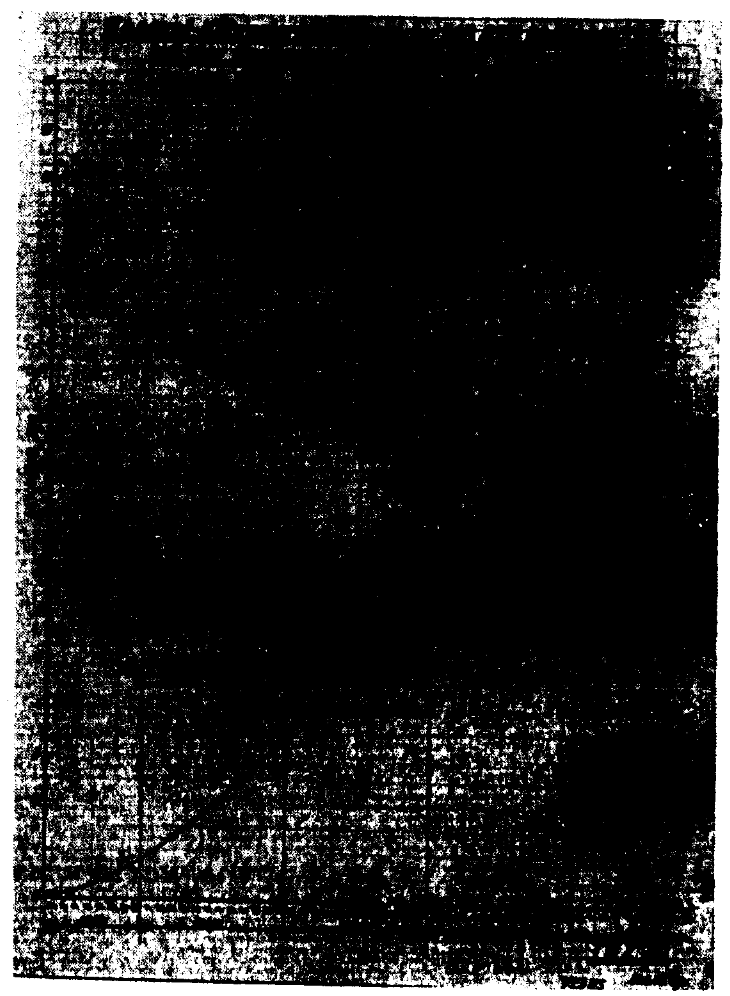


Fig. 22. Total kilometer performances of the MB. 820 engines in the service of the Deutsche Bundesbahn from 1952 to 1956.

of a branch line railcar—Fig. 18—and to a shunting locomotive built by the *Krauss-Maffei A. G.*, Munich,—Fig. 19. Thanks to the small narrow engine, this locomotive boasts first-rate visibility.

The horizontal design of engine MB 846 is increasingly gaining in importance as an underfloor engine for railcars. Fig. 20 shows the installation of one of two engines MB 846 Bb of 300 PS each in a railcar of the "DGT 600" design. In its vertical design as MB 846 Ab, the engine is frequently used for shunting locomotive operation. Fig. 21 shows a locomotive which has been built by Messrs. *Fried. Krupp*, Essen.

These examples of the fields of application for the above-mentioned engine types of the *Daimler-Benz Aktiengesellschaft* for diesel rail operation could easily be multiplied. It will be noted that the high-speed engine for all types of rail operation—shunting service, branch line operation, main line operation, express trains service—has acquired supreme importance. We have mentioned above that the further improvement of these engines has required protracted and extremely detailed development work. The results of this work can be seen in the fact that the field of application for these engines has been considerably extended.

Earlier fears that the high-speed engine would have a higher rate of wear and tear that the low-speed ones have been proved wrong by the experiences gained with the new engine types, at least. The degree of wear of the susceptible parts is kept within such narrow limits as far as the above-mentioned engine types are concerned that, after 5,000 operational hours, for instance, no part subject to wear and tear had to be overhauled because the operational tolerance limits of play and wear had been reached. In partly very hard shunting operation, engines MB 836, for instance, were in operation for over 10,000 hours without requiring an overhaul, and 6,000 operational hours have been exceeded by engine MB 846 which has not been in operation for such a long period yet.

As far as engines MB 820 are concerned, the Deutsche Bundesbahn has covered an operational distance of over 9 million miles — Fig. 22 — with very low operational failure figures due to engine defects. In this connection, it should be pointed out that some engines have covered distances of over 18,000 miles, the average figures for the past year show that 88% of the engines were in operation every month, a sign of their high efficiency. We shall report on the experiences and results gained in operation in more detail in another article.

SUMMARY

Continuing its tradition of building high-speed engines, the *Daimler-Benz Aktiengesellschaft* had developed high-speed, high-performance diesel engines with outputs up to 650 PS for rail-bound vehicles, with which impressive mileage figures have been achieved, long before the war already. After the war, three new types of high-speed high-performance diesel engines were developed which have found a wide field of application in all kinds of rail operation—shunting service, branch line operation, main line operation, express train service—and which have everywhere demonstrated their reliability whilst the wear and tear figures recorded are very low indeed. The author points out the advantages of using high-speed light engines for rail operation and describes the design of the new types of engines which meet the requirements of rail operation particularly well. A comparison with pre-war engines illustrates the progress which has been made with the construction of high-speed high-performance diesel engines. Selected examples show the varied possibilities of operation in the service of railway companies.

900 RAILWAY STATIONS TO BE ELECTRIFIED

Over 900 railway stations are to be electrified during the Second Five-Year Plan period, according to a report. The report says that from April 1, 1956, until the end of September this year electricity has been extended to 194 stations and 740 more stations are to be electrified by March 31, 1956.

The Railway-wise break-up of stations to be electrified during the Second Five-Year period is as follows: Western Railway 82, Central Railway 66, Eastern Railway 146, North Eastern Railway 140, Northern Railway 147, Southern Railway 245, and South Eastern Railway 108.

Beyer-Garratt Locomotives for South Africa

Thirty-five "G M A M" Class, 3 ft. 6 in. gauge engines of 66,800 lb. tractive effort

IN South Africa the rapid growth of industry and commerce has been matched by a similar expansion of the Railway. This has involved considerable improvements, such as doubling the line over certain sections and the increasing use of electrification where traffic density merited. During 1956 orders were placed for wagons and locomotives to the value of approximately £18,000,000 in an effort to provide the necessary rolling stock and locomotives to keep in step with other developments. The development of the South African Railways, with its heavy grades and curves, has been towards the most successful form of articulated locomotive. Since 1921 the Railways have obtained Beyer-Garratt locomotives of increasing size and power. Increases in axleload have been permissible following the improvement of track and the laying of heavy rail.

DEVELOPMENTS IN DESIGN

In 1938 development in locomotive design and power led to the introduction of 16 Beyer-Garratt locomotives of the class "GM", which were conspicuous for their exceptional hauling power on 60 lb. rail; the locomotives were designed with 4 ft. 6 in. coupled wheels with a tractive effort of 68,800 lb. for the operation of heavy trains at reasonable speeds. They were also the first Beyer-Garratt locomotives to employ the use of an auxiliary water tank, thereby obtaining the maximum possible power from the axleload, without the limitations of water supplies carried on the engine. It is from these original class "GM" locomotives that the design of "GMA" and "GMAM" has been evolved.

Altogether, 20 "GMAM" and five "GMA" class Beyer-Garratts, are already in service in South Africa, working on the Waterval Boven-Komatipoort section in Eastern Transvaal and on the Coligny line, while a further 35 "GMAM" class Beyer-Garratts have been recently completed by Beyer, Peacock & Co. Ltd. The locomotives are designed for operation with an auxiliary water tank, the water tank on the front unit being only used when the locomotive is detached from its auxiliary tank for shunting purposes. Of the locomotives now going into service, 30 are allocated to the Western Transvaal, three to the Coligny section, and two to the Zeerust line.

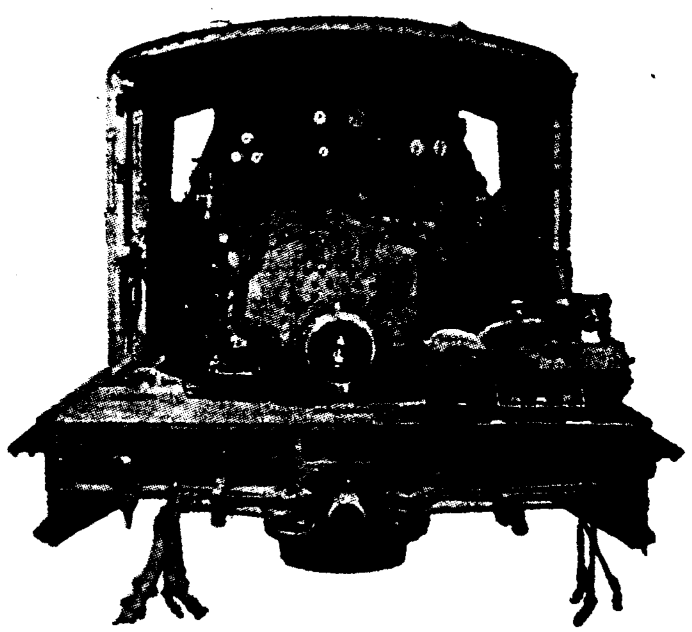
The principal difference between the "GMAM" and "GMA" classes are that the former carry 14 tons of coal and 2,100 gal. of water in the front tank, and the latter carry 11.6 tons of coal and 1,650 gal. of water. Five of the locomotives being supplied were altered on arrival to "GMA" class. The maximum coupled axleload is 15.4 tons, thus loading being made possible by restricting the weight on the bogies to 22 tons and balancing the coupled wheels so that the hammer blow is equal for all wheels, and does not exceed one ton on any wheel at 45 m. p. h. This arrangement enables the maximum tractive effort to be obtained while preventing the overstressing of the 60 lb. rail over which these locomotives are permitted to work. They can negotiate curves of 275 ft. radius with a gauge widening of not more than ¾ in. and a super-elevation of 4½ in.

BOILER DESIGN

The boiler is of all steel construction and has a grate area of 63.2 sq. ft. The inner firebox is manufactured from Colville's Double Crown plate and the stays are of Brown Bayley's Longstrand steel. The maximum dia. of the barrel is 7 ft. 3 in. outside, and the length between tubeplates 13 ft. 6½ in. The firebox is round topped, and five 3 in. outside dia. archtubes are fitted. The foundation ring is an interesting design feature, being manufactured from U shaped pressed-steel sections welded together. The fabricated ring is then welded to the outer and inner firebox shells. The outer and inner firebox shells are of completely welded construction; all the welds on the inner and outer fireboxes are examined by X-ray and photographic records are kept. Radial gusset stays are fitted at the smokebox tubeplate, and at the firebox back with radial roof stays.

Ample provision is made for washing out, especially the water spaces of the firebox, and the boiler has an inspection manhole in the top of the barrel behind the dome.

The firebars are mechanically rocked by a steam cylinder and are of the slotted table type. The front end of the grate incorporates a dropgate in the centre which is hand operated from the cab. A Standard mechanical stoker of the HT type is fitted with a



Cab layout, showing controls and stoker engine

5 in. × 5 in. engine, the latter is mounted on the boiler unit, where it is in a most accessible position for maintenance. This type of stoker which is manufactured by the Beyer, Peacock group has been fitted to a large number of locomotives of various classes on the South African Railways including the "GO," "GMA" and "25" classes.

The boiler is fed by two Davies and Metcalfe 12½ VN type injectors which discharge through top feed clackboxes of S. A. R. design. Both injectors are located on the left-hand side of the locomotive for the convenience of the fireman, and are easily accessible for maintenance. They are controlled by two quick-acting steam valves mounted alongside the boiler in front of the cab. The water inlet is taken from the centre of the cross balance pipe. This pipe connects the two external equalising pipes leading to the front unit tank and to the connections for the auxiliary water tank.

Three 3½ in. Ross pop safety-valves are mounted on the firebox and a steam release valve is located in front of the top feed. Two blowdown valves, operated from the cab, are mounted in front of the firebox and discharge through baffle drums. Isolating shut off valves are fitted between the firebox and the blowdown valves. To reduce priming a scum cock is mounted at the normal water level on the boiler backplate. Two steam turrets are mounted on the boiler in front of the cab, and the controls for the various valves are carried through to the interior of the cab. The steam supply to each turret is taken through a control valve situated on top of the boiler behind the inspection manhole, and are accessible by means of the ladder on the side of the boiler. Two water gauges are fitted of the Dewrance type in accordance with S. A. R. standards, except for one locomotive which is fitted with Klinger gauges.

The ashpan is of the single-hopper type with an air space between it and the foundation ring. A horizontal sliding door is provided at the bottom to empty the pan. A drench is attached to either side of the ashpan and is controlled from the cab.

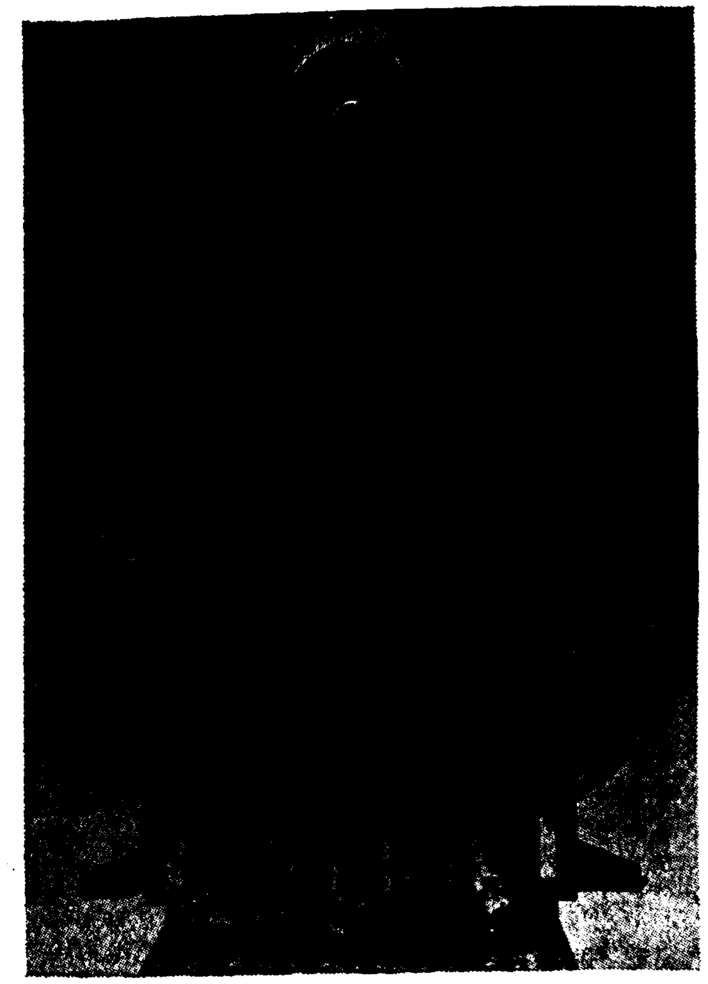
The boiler unit frame is made of two longitudinal main plates ⅞ in. thick, with flanges welded on top and bottom, braced laterally by cross-stays of ample section, and by the cast-steel pivot top centres at each end. These castings also contain the spring-loaded friction type side-bearers, which bear against the wearing surfaces on the engine unit frames.

The smokebox is of the self-cleaning type, and houses the Melesco multivalve regulator. The superheater header is of the two-piece type with 50 elements of 1½ in. outside dia.

ENGINE UNITS

The engine unit frames are of one-piece steel castings incorporating the cylinders with the inner cylinder covers, dragboxes, pivot centres and stretchers cast integrally. They are manufactured by the Commonwealth Sales Corporation and weigh about 12½ tons each. All the wheels have full flanged tyres and S. K. F. roller bearing axleboxes throughout. Those for the outer bogie and coupled wheels being of the cannonbox type while the pony truck, with outside bearings, has independent axleboxes. The right-hand truck axlebox of the front engine unit has a special cover to accommodate the generator of the Smith-Stone speedometer.

The coupled wheel axleboxes work in guides fitted with Franklin automatic wedge adjusters on one guide, and gunmetal liners on the other side. Three-point suspension is employed, and the coupled wheel and pony truck spring gear is fully compensated. The bogie and pony truck frames are one-piece steel castings supplied by the Commonwealth Sales Corporation. Both have constant resistance side movement control, and a combination of helical and laminated springing.



Front end of the locomotive, showing the layout of connections to the auxiliary water tank

One of the new locomotives with a coal train of 2,000 tons, from Witbank

The cylinders, with renewable cast-iron liners, are fitted with snifting valves and bye-pass valves, and are connected to the main steam pipes for drifting steam supplied by Sellars type drifting valves. The drain cocks are operated by steam, and thin cast-iron discs fitted on the cylinder covers provide the pressure relief. The piston and piston valve rings are of the Koppers type with segmented bronze-iron rings. Paxton-Mitchell packing is used for the piston rod glands. The piston valves are 11 in. dia., and have a travel of 7 in. The wearing surfaces of the motion with the exception of the die block are lubricated by soft grease, as are the connecting rod small end bushes and coupling rod knuckle joint pins. The crankpin floating bushes have hard grease lubrication.

Reversing is by means of a Hadfield precision power reverser fitted on the right side of the boiler frame. This steam reverser ensures that the selected cut-off is maintained constantly, and that the minimum of effort is needed to operate the gear. A large number of locomotives now in service on the S. A. R. are fitted with this power reverser, which has eased the work of the driver considerably. The pivot centres are of the Beyer, Peacock patent self-adjusting type, which have proved so successful, and completely eliminate the need for adjustment in service. As a result of experience, provision is made on these Beyer-Garratts so that the whole locomotive can be lifted as one unit in the workshops. It has been found that there is no need for the pivot centres to be dismantled for inspection when the locomotive is shopped for general repairs.

MECHANICAL LUBRICATION

A comprehensive system of mechanical lubrication is fitted including two Davies & Metcalfe F. S. A. 3 type mechanical lubricators. The latter have 24 feeds each and an oil capacity of 14 pints, but in addition, each lubricator is fed from an auxiliary oil reservoir. These mechanical lubricators feed the cylinder barrels, steam chests, piston rods, and reversing link die blocks by means of flexible pipes. The valve spindle crosshead guides, slidebars, steam and exhaust pipe ball joints and expansion joints, are also fed from the lubricators as are the Franklin compensators, coupled axlebox guide faces, compensating spring beam fulcrum pins. This comprehensive lubrication system feeds in addition the Hadfield power reverser steam cylinder, the rocking grate steam cylinder, and the Standard mechanical stoker engine.

The water tank on the front engine unit has a capacity of 2,100 gal., while the coal bunker on the rear engine unit carries 14 tons of coal. Both of these are secured to their respective engine units by the patent Beyer, Peacock spring-loaded fastening, which has resulted in greatly reduced maintenance by the prevention of the transfer of shocks from the unit frames to the tanks and bunkers. The locomotive is fitted with full vacuum brake on both engine units, and a hand brake operates on the hind engine unit only.

The ejector which is a Davies & Metcalfe H. T. type, is located on the right-hand side of the firebox outside the cab, and is controlled from the footplate. It has a release valve and an engine brake isolating valve. Two 24 in. dia. brake cylinders supplied by Gresham & Craven Limited for each engine unit, incorporate a delaying valve to ensure the simultaneous application of the brake both on the locomotive and on the train. The gravity-operated sanding is controlled by a steam cylinder on each unit. The sand being supplied to the outer coupled wheels of the leading engine unit for either direction of running.

The cab is large and commodious with ample ventilation to meet climatic conditions. A clear look out is possible on both sides of the cab when running in either direction. All the controls come conveniently to hand for the driver and the fireman. Chapman upholstered seats ensure comfortable conditions for the engine crew. A comprehensive set of gauges is conveniently in full view, and includes a steam chest pressure gauge and stoker engine and jet gauges. The vacuum gauges which are duplicated have one set on the back of the cab for running bunker first. All hot pipes are lagged to reduce the temperature in the cab. Stone's L. B. B. electric lighting equipment is fitted, the current being supplied by a T. G. 1. turbo-generator of 500 W. capacity. Besides the Tonum E headlamps at each end of the locomotive, fittings are provided to illuminate the cab, coal bunker, reversing sector and the injector overflow pipes. The locomotives are equipped with Johnson re-railing ramps supplied by Samuel Osborne.

Each locomotive after track and steam trials, has been shipped to South Africa in five major sections and is reerected at the Railway workshops at Salt River. The running numbers of these locomotives are 4076 to 4110 inclusive. They have been designed to the requirements of Dr. L. Douglas, Chief Mechanical Engineer, and the contract has been undertaken in collaboration with and under the inspection of Mr. W. H. Maass, Advisory Engineer, South Africa House, London.

Class "GMAM" being lifted in one piece in Koedoespoort workshops near Pretoria

Locomotive, with auxiliary water tank, at the head of a goods train

Auxiliary water tank wagon of 6,750 gallons capacity, used with these locomotives

The principal dimensions for the "GMAM" class locomotives are as follows :—

Cylinders (4) dia. and stroke	20½ in. × 26 in.
Coupled wheels, dia.	4 ft. 6 in.
Bogie wheels, dia.	2 ft. 6 in.
Wheelbase, each engine unit	30 ft. 4 in.
Wheelbase rigid, each engine unit	14 ft. 5 in.
Wheelbase total for locomotive	86 ft. 4 in.
Length over buffers	94 ft. 4 in.
Width over boiler unit platforms	10 ft.
Height of top of chimney above rail	13 ft.
Height of boiler centre above rail	8 ft. 6 in.
Water tank capacity (front unit only)	2,100 gal.
Fuel capacity, coal bunker hind unit	14 tons.
Boiler barrel, dia.	7 ft. 3 in.
Length between tubeplates	13 ft. 6½ in.
Evaporative heating surface, tubes	2,960 sq. ft.
Evaporative heating surface, firebox, including arch-tubes	237 „ „
Evaporative heating surface, total	3,197 sq. ft.
Superheater heating surface, inside	747 „ „
Heating surface, total	3,944 sq. ft.
Grate area	63.2 sq. ft.
Boiler pressure	200 lb. per sq. in.
Tractive effort at 85 per cent boiler pressure	68,800 lb.
Maximum axleload	15.4 tons.
Adhesive weight	120.4 tons.
Total weight, in working order	190.2 tons.

METRIC SYSTEM OF WEIGHTS AND MEASURES

The Government of Bombay in consultation with the Government of India, has decided to introduce the metric system of weights and measures from October 1, 1958, in respect of sugar, salt, Vanaspati, coal; charcoal, fuel, wood, iron; steel; cement, cloth, biscuits, confectionary, paints; varnishes and washing soap.

The change-over, in the first instance, will be limited to the cities of Bombay, Poona, Ahmedabad, Rajkot, Baroda, Nagpur, Aurangabad, Sholapur and Kolhapur.

Multiple-Unit Diesel Trains for British Railways

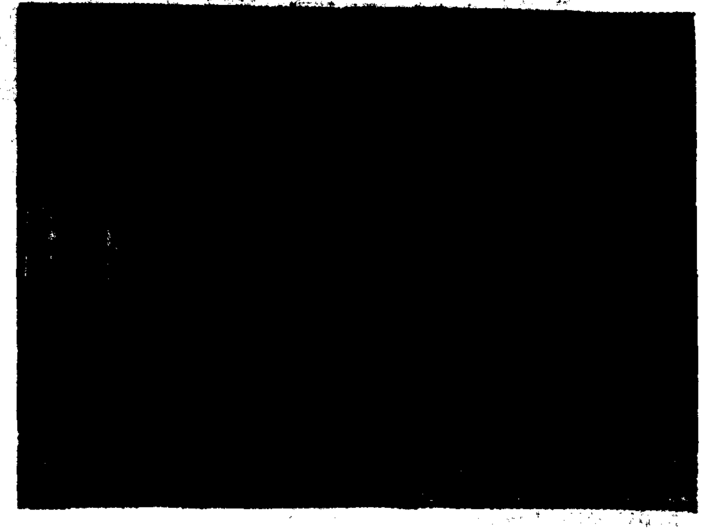
300-h.p. sets with bodies of box-girder construction

THE first of the Wickham multiple-unit diesel train sets, built to the order of the British Transport Commission as part of its modernisation programme, is now about to enter service.

As the power units, transmission, control gear and method of internal heating follow the design already standardised by British Railways, little description of these units is required; the power plant consists of two 150-b.h.p. B. U. T. Leyland six-cylinder horizontal engines with fluid couplings each driving via a cardan shaft fitted with free wheel and an air-operated four-speed Wilson epicyclic gear box; the drive from each gear box to its adjacent bogie is by Hardy Spicer propeller shaft to B. U. T. double-bevel reverse box mounted on the inner axle. The various auxiliary drives to fan, Stone's dynamo and Clayton exhauster also follow the standardised pattern, and the general layout can be followed by reference to the underfloor view on page 19, which also shows the location of the two Smith's heaters.

This and other illustrations are made possible by the use of fully rotating fixtures in which the body frame is initially fabricated by electric welding. Similar fixtures are used in the erection shop for easy fitting of wiring, pipework, engines and transmission, the cars being revolved to the most suitable position for the work in hand.

Power car of the new Wickham multiple-unit diesel trains



Interior sheeting of roof with body frame mounted in rotary manipulator

USE OF ALUMINIUM

Other constructional variations from usual in the equipment are the use of aluminium for both fuel and vacuum tanks, which are electrically welded by the argon arc process, and the use of solid drawn aluminium tubing for the vacuum brake pipe layout.

Compressed air control piping is also of solid drawn tube; steel is used in this instance, eliminating to a large degree troubles due to scale loosening and choking control valves. Ermeto couplings are used for connections.

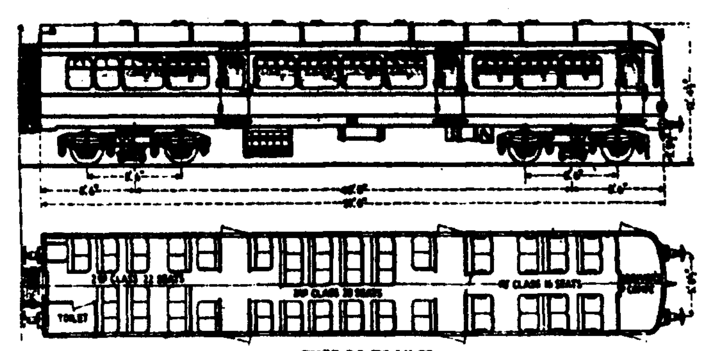
Controls are of standard B. U. T. type arranged with throttle controller on the left and gear change on the right, Tachometers, vacuum and pressure gauges are mounted between on a sloping panel in front of the driver, this panel also carrying the main switch, main switch indicator light and changeover switch for the revolution counter. Indicator lamps are mounted on a vertical panel, on the left and at an angle to the driver so that they can be observed without craning the neck, being at the same time clear of the driver's ahead vision. On the right and within comfortable reach of the driver's hand is the Gresham & Craven vacuum brake valve; the hand brake wheel also is within the driver's reach without leaving his seat.

A [illegible] Chapman driving seat is fitted; this is adjustable for height and can also be moved forward or backwards by the driver when seated.

BODY CONSTRUCTION

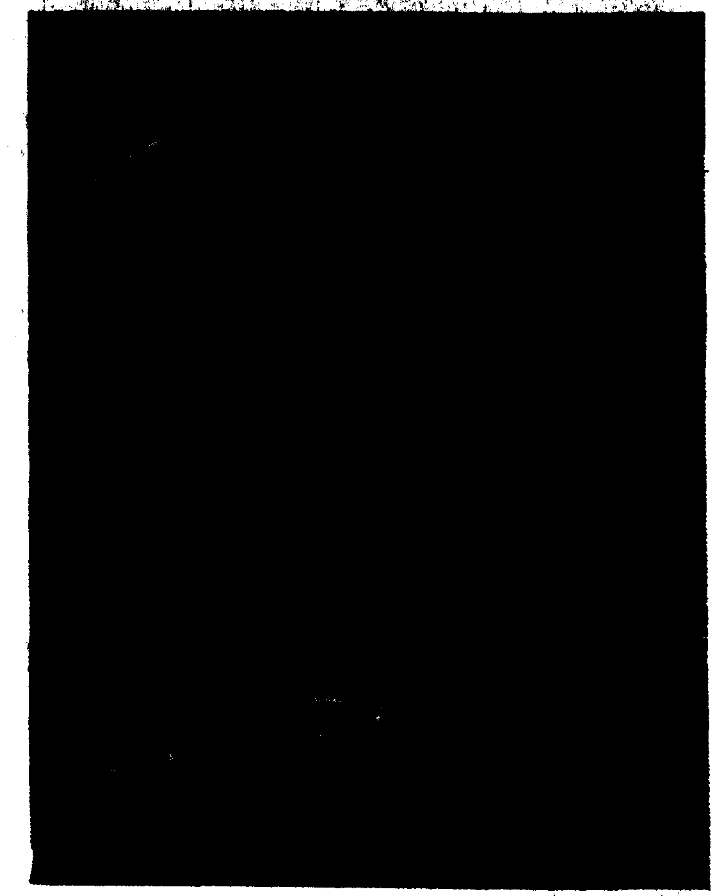
The major variation from standard practice is the body construction. The unit was selected by the British Transport Commission for its recent exhibition of rolling stock at Battersea and to illustrate this the trailer was shown in skeleton form. The construction follows in principle the design first adopted by Wickham in 1936 for use on a South American mountain railway, where weight saving is of vital importance. This body has given no trouble at all and is still in service. Other similar cars are operating in Bolivia, Peru, Colombia, Venezuela, Jamaica, and in East and West Africa. No underframe is used; the all-steel body skeleton forms a tubular stressbearing box girder designed to take all bending, torsional, buffing and traction loads. The various items of equipment are attached by means of steel brackets welded on as necessary.

The unit of construction of this girder is solid drawn square steel tubing with a wall thickness of approximately $\frac{1}{8}$ in. (10-gauge) and as each tube is, during assembly and welding, completely closed to atmosphere no internal corrosion can occur. The 16-gauge corrugated steel flooring is welded in to the tubular longitudinal and cross [illegible] giving additional strength [illegible] loads. The roof stick [illegible] from the fact that [illegible] width and contour [illegible] make press tools for every [illegible] the question. The construction [illegible] apart by a zigzag [illegible] only very simple [illegible] and is very [illegible]



TYPE 82 TRAILER

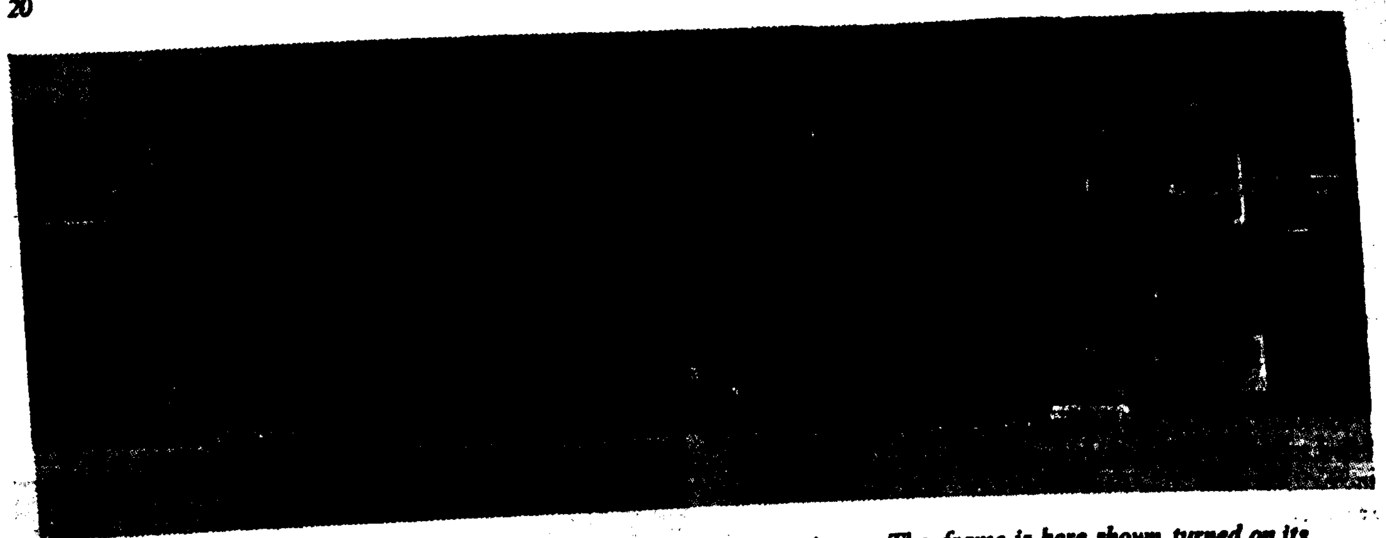
Layout of composite first and second class trailer car



Integral body frame under load test: the spring-loaded bolts are attached to the floor of the workshop

load of $1\frac{1}{2}$ tons spread over the centre six inches produces a deflection of only $\frac{5}{16}$ in. A further advantage is the ease with which wiring conduit, supply and control services can be run through.

It is this rigid stress-bearing structure that makes possible the use of rotating fixtures not only when welding and panelling but also in fitting the power plant and other necessary services.



Centre section of frame with underside equipment, less engines. The frame is here shown turned on its side in the rotary manipulators

Interior of power car showing arrangement of second class seating and draught deflecting partitions at entrance doors

LOAD TESTING

The Illustration on page 19 shows the load testing arrangements. These comprise strong-backs distributed over the railcar floor area, spring-loaded bolts being passed through this floor and attached to eyebolts grouted in concrete. Load is applied by hand wheels on each strong-back through calibrated springs, the body skeleton being supported at the bogie centres.

INTERIOR DECOR

Both exterior and interior panelling is of 16-gauge aluminium sheet, the inside panelling up to luggage rack level having Warerite bonded to the surface. The roof covering over the luggage racks is corrugated rubber; roof panels are Vynide cloth covered. Both first and second class compartments have the Warerite interior finish, the former simulating walnut and the latter light oak. Very few panel fixing screws are visible, all others being covered at the top by the tubular aluminium luggage racks and at the bottom by the heater duct, special extruded aluminium sections with suitable locating grooves and special section window frames providing neat and rattle-proof retaining fixings.

The Widney windows, apart from the special frames, are of standard British Railways design with polished and anodised aluminium finish. These windows have the standard sliding top lights with deflectors at the top for ventilation purposes, further ventilation being supplied by Airvac roof ventilators, the roof openings being concealed by the longitudinal troughing which also supports the interior lights.

At each entrance door draught deflector partitions are arranged, these being fitted with glass panels and shaped to give a light and spacious appearance.

The corrugated steel floor is filled with sprayed asbestos for sound insulation and then covered with asbestos filled flame-proofed hardboard, the final floor covering being of fire-resistant rubber sheeting. In the power car suitable traps fitted with locks are arranged over vital parts of engine and transmission but all normal servicing can be carried out from the side or over pits.

SEATING

Steel tubular framed seats by G. D. Peters of Slough are arranged three and two in the second class compartment; upholstery is of patterned green moquette with leather trim on Dunlopillo. The first class seats arranged two and two are of similar type and make, but afford a suitably greater degree of comfort. The finish on these is blue moquette with leather trim.

The guard's compartment in the power car is laid out according to British Railways standards. A seat, electric food warmer, first-aid kit and accident equipment including ladders are provided.

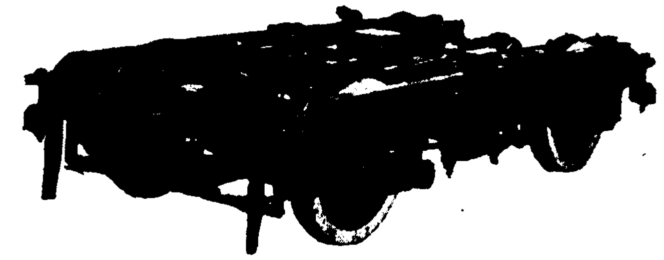
GENERAL LAYOUT

The general layout and overall dimensions in accordance with British Railways requirements are shown in the general arrangement drawing. From this it will be noted that as the car and trailer will be operated as a unit only one lavatory is provided. This is in the trailer, and first class accommodation is also confined to the trailer. Communication between the two cars is by a standard bellows vestibule supplied by A. G. Wild & Co. Ltd. Driving controls are duplicated and fitted to one end of the power car and the opposite end of the trailer car in partitioned-off compartments fitted with lockable sliding doors.

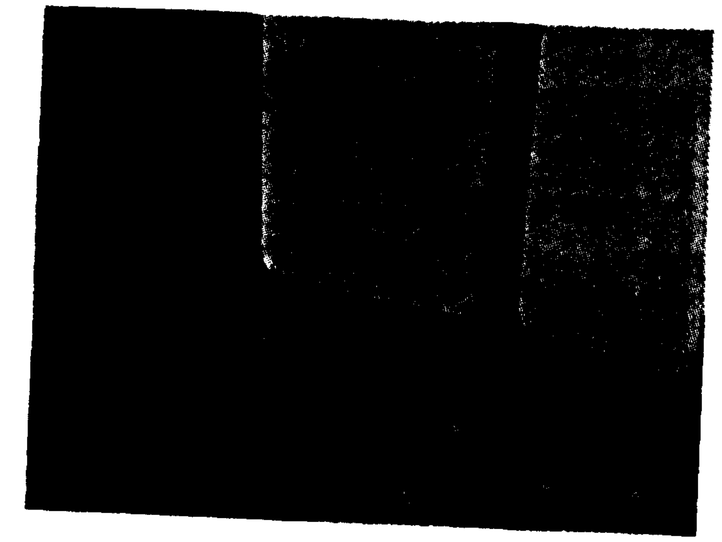
BOGIES

Little comment is needed on the bogies, these being of standard Derby design modified in certain details by welded assemblies in place of riveted construction and the fitting of Woodhead-Monroe hydraulic shock absorbers between bolster and body. Lighter springing is made possible by the weight-saving achieved with the Wickham method of construction.

Top speed of the unit is the standard 65 m. p. h. at maximum governed engine speed of 1,800 r. p. m.; but, as the tare weight of car and trailer is only just about 47 tons, better acceleration and lower fuel consumption can be confidently expected. Full load trials have still to be completed so full data are not yet available, but on the initial runs the riding and general performance have proved very satisfactory.



General view of driving bogie



Interior of driver's compartment

PRINCIPAL SUB-CONTRACTORS

Vacuum brake equipment	.. Gresham & Craven Limited
Buffers	.. Oleo Pneumatics Limited
Engines and transmission	.. British United Traction Limited
Warerite panels for interior	.. Bakelite Limited
Axleboxes	.. British Timken Limited
Wheels and axles	.. John Baker & Bessemer Limited
Steel castings	.. Lake & Elliot Limited
Speed indicator equipment	.. J. Stone & Co. Ltd.
Flooring material	.. Rubberware Limited
Gangway vestibules	.. A. G. Wild & Co. Ltd.
Flooring section	.. Metal Sections Limited
Windows	.. Hallam Sleigh & Cheston Limited; Beckett, Laycock & Watkinson Limited
Rubber mouldings	.. Waterford Rubber Manufacturing Company
Springs	.. Turton Bros. & Matthews Limited; Jonas Woodhead & Sons Ltd.
Aluminium sheets	.. British Aluminium Limited
Aluminium tubes, and sections	British Aluminium Limited; Northern Aluminium Limited
Screw couplings	.. W. & E. Moore Limited
Compression joints	.. British Ermeto Corp. Ltd.
Aluminium pipe fittings	.. William E. Cotton Limited
Seats	.. G. D. Peters Limited
Combustion heaters	.. S. Smith & Son Ltd.
Asbestos insulation	.. Sprayed Insulations Limited

(Continued on page 22)

FACTORS GUIDING THE SPECIFICATIONS OF STEAM LOCOMOTIVES

By Sunil Chandra Banerjee, G.I.Mech.E.(Lond.), A.M.I.E. (India)

THE development of industry and growth of population were the chief factors which created the need of more motive power during the past centuries. The inception of the railways may be directly traced to this natural demand; and the demand for utility, speed, safety and reliability is becoming more and more prominent every day. The subject of mainline electrification has been very prominent for the last decade, but before accepting this principle as a practical proposition, the heavy initial cost of providing suitable track and power equipment, and the difficulties in maintaining the continuity of service naturally trend the engineers to use steam locomotives (which is a self-contained prime-mover) as the hauling units. The progress made by the locomotive engineers during the past 125 years is commendable; the speed and weight of the locomotives have increased enormously. The total weight of locomotive No. 1 was only 11 tons, the total weights of the "Pacific" and "Mikado" locomotives exceed 170 tons and 190 tons respectively, the "Garrats" weigh more than 200 tons and the giant "Mellets" weigh more than 225 tons. Referring to the inception of the first passenger locomotive which travelled at a speed of 10 miles an hour to the present day speed to 120 miles per hour we find the evolution of steam locomotives in a few words. The duties of this versatile power unit vary from handling heavy express passenger loads of 500 to 600 tons at a mean speed of 60 m. p. h. to the freight loads of 2000 tons at a speed of 30 m. p. h. to the shunting operations in large yards, and consequently nowadays a Railway Engineer is confronted with the difficult problem of specifying the locomotives for the different types of services he likes deploy her in. It is a complex problem depending on a large number of factors, and a compromise has to be adjusted among the various points. The following points may be interesting :—

1. *Conditions Imposed by Traffic Dept.*—These relate to the type of rolling stock to be handled and the speed of run. These two broad points, however, depend upon the following :—

(i) *Engine, tender and train resistance*: The starting resistance of the locomotive is the limiting factor in this case, because, once the starting resistance is overcome, the unit goes on moving. This factor depends upon the following :—

(a) Type of bearing (plain, roller or some special design).
(b) Type of lubrication (oil or grease and syphon or forced).
(c) Time the vehicle is required to remain standing in between two runs.
(d) Climatic condition.

For plain bearings the starting resistance is 15 to 20 pounds per ton in British practice and 15 to 28 pounds per ton in American practice. The starting resistance for roller bearings is 4.5 lbs./ton. The resistance drops considerably after a complete film of lubricant is restored between the rubbing surfaces. The internal resistance of the locomotive due to friction of pistons, valves, valve gears and other moving parts are practically constant at the different "cut offs" of the valve (for the different expansion of steam in the cylinders and according to Lawford Fry it is estimated to be about 1% of the adhesive weight.

(ii) *Track Resistances*: This factor includes the following :—

(Continued from page 21)

Leathercloth	.. Imperial Chemical Industries Limited	Panelling rivets	.. Aircraft Materials Limited
Paints and varnish	.. Docker Brothers Limited; Vulcan Products Limited	Luggage rack brackets	.. Deans & Son Ltd.
Steel tube (square section)	.. Accles & Pollock Limited	Hinges	.. Beaton & Sons Ltd.
Heater ducting and roof ventilators	Greenwood & Airvac Limited	Shock absorbers	.. Jonas Woodhead & Sons Ltd.
		Fire protection equipment	.. Graviner Manufacturing Co. Ltd.

(a) Friction between tyre flange and rail;
(b) Resistance due to depression of track which has the effect of making the locomotive to climb a continuous grade;
(c) Minor resistances due to the impact at rail joints, deformation of rail and tyre at the point of contact and miscellaneous vibrations;
(d) Gradient resistance—the magnitude of which is $\frac{\text{Rise} \times 2240}{\text{distance}}$ lbs. per ton
(e) *Curve resistance*—This factor depends on the length of the wheel base, being greater for longer wheel bases. For an eight coupled tender engine on broad gauge the curve resistance is about 2.1 lbs. per ton per degree of curvature of the track for average conditions. When considering resistances, it is necessary to know whether the curves are compensated and whether the maximum grade and minimum grade are co-incident, but it is always best to base the calculations on the combination of the worst grade and curve.

(iii) *Wind Resistance*—If V = speed in miles per hour

A = sectional area of the locomotive in sq. ft. (usually 120 sq. ft. for American locos)

Wind resistance = $0.002 \times V^2 A$ lbs.

In an actual test by the Research Dept. of the German State Railway with a "Baltic" type locomotive (4—6—4) it has been found that a saving of about 20% (i. e., about 550 H. P.) of the developed horse power at 93 m. p. h. was obtained by the adoption of a streamlined casing. Even partial encasing of the front and the motion parts give considerable reduction in Air resistance at high speeds.

(iv) *Acceleration Resistance*—This is calculated on time basis and distance basis i. e., for express service this is calculated on time basis and for suburban service this calculated on distance basis. While calculations are made for resistance due to acceleration the rotary inertia of the wheels and axles must be taken into consideration.

(a) Acceleration resistance on a distance basis =

$$80 \frac{M^2 - m^2}{S} \text{ lbs./ton.}$$

(b) Acceleration resistance on a time basis =

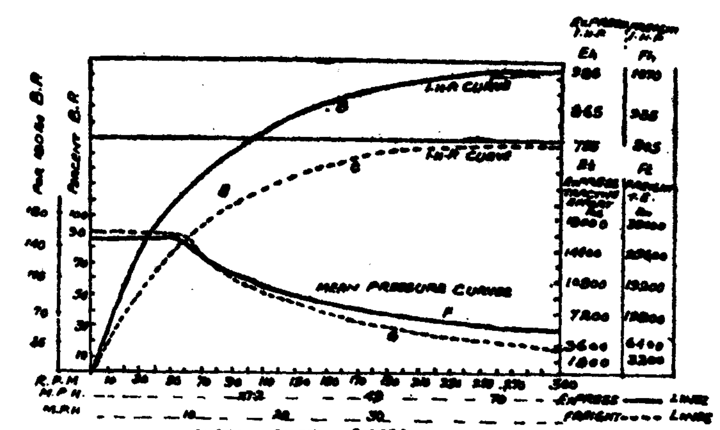
$$108 \frac{M - m}{t} \text{ lbs./ton}$$

where M = Higher velocity in miles per hour
m = Lower velocity in miles per hour
S = Distance in feet over which the acceleration takes place.
t = Time in secs. during which acceleration takes place.

(v) *Tractive Effort, adhesive factor, speed and power*—At any instant the tractive force of a locomotive

= Total resistance of locomotive and train.
= Rolling resistance + Gradient resistance + curve resistance + wind resistance + internal resistance + acceleration resistance.

Once the train has overcome the initial starting resistance, the tractive force is always in excess and this excess force causes the acceleration. After a certain speed is reached the tractive force of the locomotive falls rapidly but the resistance continues to increase. The excess accelerating force diminishes as the speed increases and reaches a point where the tractive force is equal to the total resistance.



CHARACTERISTIC DIAGRAM
FIG. 1

T = Tractive Efforts in lbs.
D = Cylinder dia. in inch.
S = Piston Stroke in feet.
P = Pressure of steam in lbs. per sq/in.
W = Driving wheel dia. in feet.
R = Ratio of Cylinder Volumes (between 2.35 and 2.4)

for a two cylindered simple locomotive the expression for tractive

$$\text{Effort} = \frac{D^2 SP}{W}$$

for a 3 cylindered engine $T = \frac{3}{2}\frac{D^2SP}{W}$

for a 4 cylindered engine $T = 2\frac{D^2SP}{W}$

for a 4 cylindered compound engine $T = \frac{1.2\,D^2SP}{W\,(R+1)}$

the ration of adhesive weight to tractive effort in the two cylindered engine should be more than 4:1. In the case of multi cylindered locomotives, however, the ration may be as low as 3.5 : 1 for more even torques.

Coupled wheels are necessary for the exploitation of tractive efforts. In order to have a great drawbar pull the locomotive should have a good number of coupled wheels of comparatively small diameter.

N = Number of Coupled axles.

T = Tractive effort in lbs.

L = Permissible axle load in tons per axle.

$$N = \frac{5\,T}{2240\,L}$$

If V = Velocity in m.p.h., generated horsepower $= \frac{TV}{375}$

With the above considerations in mind let us now find the power of a locomotive necessary in hauling an express load of 600 tons on the level at 65 m. p. h. and up a grade 1 in 100 at 30 m. p. h. The limiting load per axle = 18 tons.

A rough estimate shows that three coupled axle are required.

The available adhesion = 54 tons.

Allowing a four wheeled bogie the total weight may be taken as 90 tons. The weight of the tender may be allowed for at 60 tons,

Weight on coupled axles = 54 tons.

Weight of bogie and tender = 94 tons.

Total Weight of engine and tender = 150 tons.

Resistance on level at 65 m. p. h. :—

(i) Engine (coupled axles) taken at 18 lbs./tons.

(ii) Bogie and tender are taken at 6 lbs./ton

(iii) Wind resistance on a cross-sectional area of 110 sq. ft. at 65 m. p. h. = .002 × 65² × 110 lbs.

(iv) Train resistance at 13 lbs./ton = 600 × 13 = 7800 lbs.

Total Resistance = 54 × 18 + 94 × 6 + .002 × 65² × 110 + 7800

= 972 + 564 + 924 + 7800

= 10270 lbs.

$\therefore$ Power of the locomotive $= \frac{10270 \times 65}{375} = 1906$ H.P. at 65 m.p.h. on a level run.

Allowing for a two cylindered locomotive with a boiler rating of 200 lbs. per sq. in. we find from the H. P./R. P. H. chart that house power per sq. ft. of heating surface at 300 r. p. h. is 0.8.

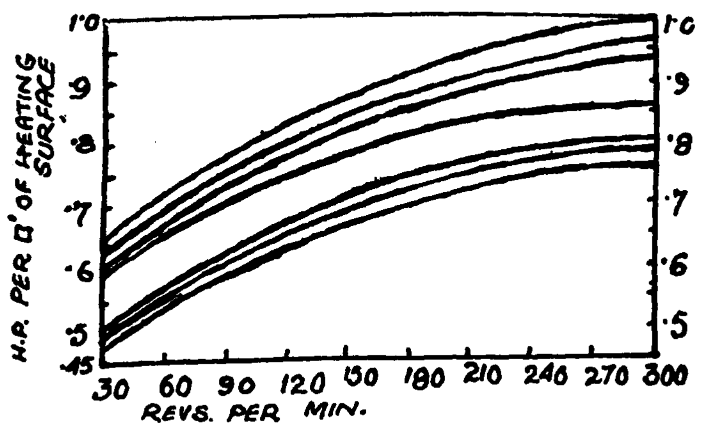


Fig. 2

$\therefore \frac{\text{Heating Surface}}{\text{Grate area}} = 50$ to 55 for express loco and 55 to 70 for freight locomotive.

$\therefore$ Grate area $= \frac{2382.5}{55} = 43.3$ sq. ft.

The superheater surface can be obtained in the manner,

$$\frac{\text{Evaporative Heating surface}}{\text{Superheater surface}} = 2.5 \text{ to } 3.$$

Then super-heater surface = 76o sq. ft.

From the tractive effort formula, with a driving wheel of 72″ diameter and 13″ crank the diameter of the cylinder is 20″.

Resistance up a grade 1 in 100 at 30 m. p. h.

(i) Engine and coupled axles at 18 lbs. per ton = 972 lbs.

(ii) Bogie and tender at 6 lbs. per ton = 564 lbs.

(iii) Wind resistance = 198 lbs.

(iv) Train resistance at 12 lbs./ton = 7200 lbs.

(v) Gradient resistance $= 750 \times \frac{2240}{100} = 16800$ lbs.

$\therefore$ Total resistance = 972 + 564 + 198 + 7200 + 16800 = 25734 lbs.

$\therefore$ Power required $= \frac{25734 \times 30}{375} = 2058.72$ horse power

at the lower speed of 30 m. p. h. or 120 r. p. m. of the crankshaft, horse power per sq. ft. of heating surface = .74.

$\therefore$ heating surface $= \frac{2058.72}{.74} = 2782$ sq.ft.

Similarly grate area $= \frac{2782}{55} = 50.58$ sq. ft.

Superheater surface $= \frac{2782}{3} = 927$ sq. ft.

The dimensions at lower speed suits quite well with those at higher speed.

(2) *Civil Engineering Limitations*—These limitations consist of the following :—

(a) Load per axle in tons = 1/5 × weight of rail in lbs. per yard.

(b) Load per foot run on rigid wheel base.

(c) Load per foot run on total wheel base.

(d) Load per foot run over buffers or couples.

10% to 20% overload may be allowed when the locomotive is provided with three or more cylinders in conjunction with a small proportion only of the reciprocating masses balanced with a drive through reduction gears or some other special feature likely to reduce the range of kinetic variations above and below the static axle load occurring with the twin cylindered locomotive of conventional design. The heaviest passenger locomotive of B. E. S. A. convention running in India to-day the xC class has an axle load of 19.8 tons plus 66% over balance giving a total of 14.5 tons per wheel.

(3) *Rail Gauge*—This factor is extremely important for the railways in India where a larger number of rail-gauge has been adopted in order to meet the different conditions of the soil and traffic at the various regions of the country. This factor determines the overall width and the speed of the locomotive. The speed limit is small for narrow gauges and for this reason the inside cylinders should not be employed in this case.

(4) *Loading Gauge.*—This factor primarily deter mines the overall dimensions of the locomotive. The locomotive must clear the loading gauge when standing on severer curve she is allowed to traverse, and attention should be paid to the effects of worn out-tyres, weakened springs etc., on Vertical clearances.

(5) *Gradients and Curves.*—These factors with the type of load to be hauled determine the rigid wheel base, flexible wheel base, lateral clearances allowed and the steaming capacity of the boiler.

R = Radius of curve

B = Rigid wheel base

C = Permissible lateral movement by total flange clearance.

$C = \frac{B^2}{2R}$ other calculations have been shown previously.

(6) *Permanent Way*—This factor is considered for the suspension gear of the locomotive. The fundamental difference between chaired and spiked permanent way and the relative standards of maintenance achieved largely decide the question, whether compensating gears should be fitted or omitted.

(7) *Fuel.*—The factor of fuel is extremely important for putting down specifications for firebox, heating surface and artificial draught apparatus. In modern high power locomotives mechanical stokers are also specified. Ohio and Chespicko Rlys. have advanced a step further by putting pulverised coal firing in their steam turbo-electric locomotives. Iran Rlys. use oil fired locomotives and the locomotives switching over the Florida Coast use wood and bagasse in their fireboxes. The fuel consumption can be

obtained from the rated power required for working the maximum train load and this factor determines the tender capacity between two successive refuelling stations. It will not be out of the place to mention that the present policy of the Government of India is to use low grade coal in steam locomotives, and the locomotives will evidently required wide firebox with extra combustion zone and large heating surface. This tendency of using low grade coal in locomotives has developed the pacific type of locomotive boilers. It may be remembered that an express locomotive with a grate area of 25 sq. ft. will, when running at 60 m. p. h. consume about 35 lbs. of coal, 30 gallons of water and 5500 c. ft. of air per minute.

(8) *Water*—The longest distance between the watering stations and the water consumption, with necessary factor of safety, determines the capacity of the water tank. The chemical properties of water, together with the capacities of the treatment plants already in use should be considered for the specification of the tanks, strainers, injector, boiler stays etc. Locomotives used in the desert areas and sea coasts should be provided with condensing equipments.

(9) *Climatic Conditions*—The atmospheric humidity affects the factor of adhesion and hence this factor is necessary for providing the engine with steam or gravity operated sanding gears. Locomotives running in desert areas are to be fitted with dust shields etc., in order to save the journals from grit and dust. Suitable steam heating coils are necessary for mechanical lubricators in engines running in arctic area.

(10) *Mechanical Engineering Limitations*—This is necessary for specifying the details of the locomotive. The overall length must be determined from the existing turn table capacity and the total weight must be limited to the capacity of the lifting machines. The lengths of pits and traverses, availability of machine tools, coaling equipments, water columns, quality and frequency of servicing depot etc., all should be considered.

Reliability is primarily essential. Every detail must be so designed that it assumes the simplest form. It must be rendered fool-proof especially when operated by inexperienced hands. The details must be accessible for inspection and servicing and must be sufficiently strong to withstand the pressure and load. Reasonable allowance must be provided for any reduction in section due to wear and tear and consequent machining. The factor of safety must be sufficient to cover any bad maintenance—both of the locomotive and of the permanent way. The reciprocating parts must be well balanced and any unproductive weight from the point of power output should be dispensed with. Departure from the existing standard involves expenditure, the hollow spoked coupled wheels of the W. P. class locomotives manufactured by the Montreal Locomotive Co., Canada are worth mentioning. The design is bad where numerous pipes have to be taken down before the wheel and axles may be removed or streamlight joints be broken in order to repair other parts. Provisions for lifting the locomotive must be provided. The number, diameter and location of the boiler wash-out plugs must be carefully determined. The footplate fittings must be simple, and accessible and nothing should obstruct the driver's vision. A high longitudinal centreline of the boiler allows for accessibility and inspection, but a low centre of gravity of the locomotive provides for a steadier run. Outside cylinders are preferable for easier attention and replacements. Each cylinder should preferably be individual blocks from economic point of view. The cylinders of the W. P. class locomotives manufactured by the Montreal Locomotive Co. are two in one block and possess the disadvantage that the entire block requires replacement when a single cylinder is damaged. Walscheart Valve gear with piston valves absorb about 8 to 10 horsepower, the slide valve absorbs 12 to 15 h. p. and the cam operated poppet valves absorb 4 to 5 h. p. while detailing the specifications, it must always be remembered that the cost of alloy steel is 40% more than carbon steel.

Apart from the above, there are other stipulations e. g., Government Regulation regarding the boiler fitting, couplings, welding processes, spark arresters etc., which must be considered carefully before finalising the specifications.

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Modern Trends in the Production of Wheels and Axles

By C. C. Lilleyman, A.M.I. Loco. E., Owen & Dyson, Ltd.

THE modernization, re-equipment and development of railways the world over has resulted in a continual demand for wheel and axle sets with higher standards of accuracy and finish. This has necessitated bold thinking with regard to the installation of suitable plant to meet these requirements. Advantage must therefore be taken of the latest developments in machine tools and processes and their potential must be fully exploited by the practical application of the most up to date knowledge of cutting tools and techniques if increased output with better quality control is to be achieved. The considerable advances in machine tool design embodying the development of mechanical and electronic copying principles has made this more easily possible.

AXLES

It is perhaps in the finish machining of axles that maximum benefit has accrued from the precision control over copy turning achieved through servo-operated mechanisms. Not so many years ago, the quality of surface finish and the degree of dimensional accuracy obtained on axles depended to a very large extent on the standard of skill of the individual operator. Now, however, axles of highly complicated form—as in the case of axles for use with axle hung traction motors—are machined economically and with consistent accuracy as an automatic process.

Wheel set for 1250 h. p. A1A–A1A Diesel Electric Loco.

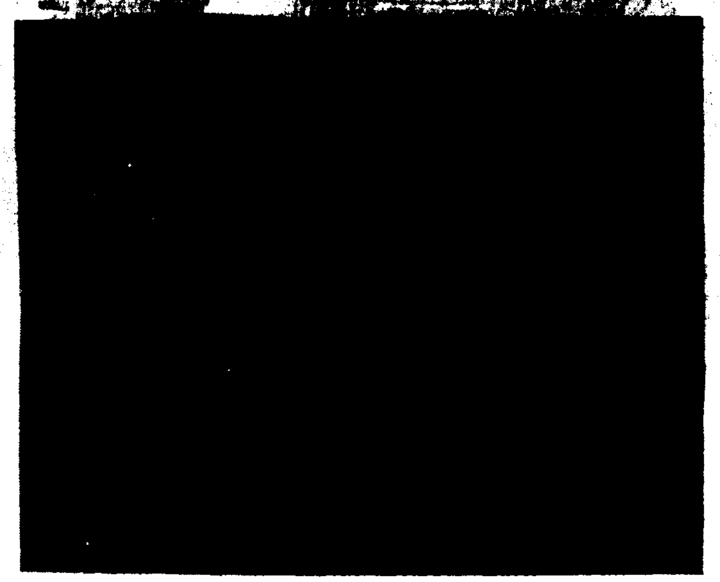
Since the war, the advantages of roller bearings have become apparent and increasing numbers of railway vehicles of all types are now being equipped with this type of axlebox. The importance of this development was early recognised and some six years ago equipment was installed at Owen & Dyson to process this type of axle on a mass production basis whilst maintaining the high standard of surface finish and dimensional accuracy demanded by the roller bearing manufacturers.

Working in conjunction with a battery of copy turning lathes, a special centreless grinding machine—the only one of its kind in the country engaged on this operation—completes a cycle of machining operations by finishing the wheelseats and journals to exceptionally fine tolerances. It is capable of dealing with all types of axles and extreme accuracy, both diametrically and in profile, is guaranteed by this method. The machine consists essentially of built-up grinding wheels on a patent spindle of a special design. The form of the grinding wheels is rigidly maintained by means of a special device with micrometer adjustment attached to a follower which is actuated by a profile cam of true form. The actual grinding operation is semi-automatic and axles can be finished ground on journals and wheelseats in an average time of just under 1 1/2 minutes per end, with a guaranteed diametrical accuracy within .0002″.

WHEELS

The set up for the machining of wheels—either the solid one-piece or built-up type with tyre and disc centre—comprises boring and turning mills, finish boring mills, trepanning or drilling machines, suitably arranged to give a balanced production.

With the exception of the dished web—which is usually left in the "black" (as rolled) condition—wheels are completely machined prior to being pressed on to the axle. This is done at two settings—first and second side—on duplex boring and turning mills capable of very heavy and often intermittent cutting whilst maintaining high speed production. These mills were developed as a result of many years pioneer work in [illegible] direction and incorporate hydraulic controls for simplicity with maximum efficiency. When webs of wheels are required to be profile turned, the operation is carried out on boring and turning mills having built in [illegible] contouring mechanism [illegible]



Wheel set for multiple Unit Diesel Cars

under precise control, intricate profiles are machined with extreme accuracy. Indeed, this is the most economical and satisfactory method of producing wheels that are required to be machined all over. In view of the high quality finish required with consistent dimensional accuracy to very close limits, finished boring is carried out as a separate operation on specially designed high speed mills.

A feature indirectly contributing to efficient wheel production is the installation of a series of underground conveyors on to which swarf is directly discharged from the production machines, to be transported to an outside depot and automatically crushed.

The intelligent application of the correct cutting materials is of course, of vital importance, and knowledge gained through extensive trials is applied to determine the most favourable materials, tool forms, cutting speed and feed and other factors closely associated with economical output.

ASSEMBLY

It is [illegible] no substitute for experience. In no other [illegible] the production of wheel and axle sets [illegible] as in the actual assembling of [illegible] axles. Messrs. Owen & Dyson [illegible] years of specialised experience in this field has proved of [illegible] dealing with the many varied and [illegible] assemblies born of modernisation in [illegible] electrification and dieselisation [illegible]

Certain [illegible] govern [illegible] requirements necessitate [illegible] able ingenuity. In additi[illegible] such components as gear wheels, [illegible] axleboxes, motor suspension sleeves, cannon [illegible], and inner and outer roller bearings must also on occasion be assembled on to the axle; quill drives have sometimes to be catered for and the finished product often bears little resemblance to a normal simple wheel set. These all bring a challenge to the press man's art and the essential accuracy to which they are assembled is indeed impressive.

After final assembly, wheel sets are put through a specially designed dynamic balancing machine which is capable of detecting and indicating the exact position of any unbalanced mass in the wheelset. Small compensating weights are then added to restore the balance; in these days of increased speeds and roller bearing axleboxes correct balancing is of even greater importance than before.

Railway modernization and re-equipment programmes are testing the ingenuity and resources of manufacturers of locomotives, rolling stock and their components. An essential policy of increased output with better quality control and improved flexibility in production is enabling Owen & Dyson to meet this challenge and thus, in a specialised way, to assist in the economic development and expansion of countries the world over.

BRITISH UNITS			METRIC UNITS		
Hot Face Temp. °F	Heat Loss BTU/sq. ft./hr.	Percentage Heat Saved	Hot Face Temp. °C	Heat Loss K. cal/sq. m/hr.	Percentage Heat Saved
200	45	84.4	100	140	84.5
300	91	85.2	150	249	85.2
400	126	88.2	200	332	88.2
500	177	89.2	250	455	89.1
600	223	90.7	300	560	90.5
700	287	91.2	350	718	91.0

LONG LIFE AND LOW MAINTENANCE COSTS

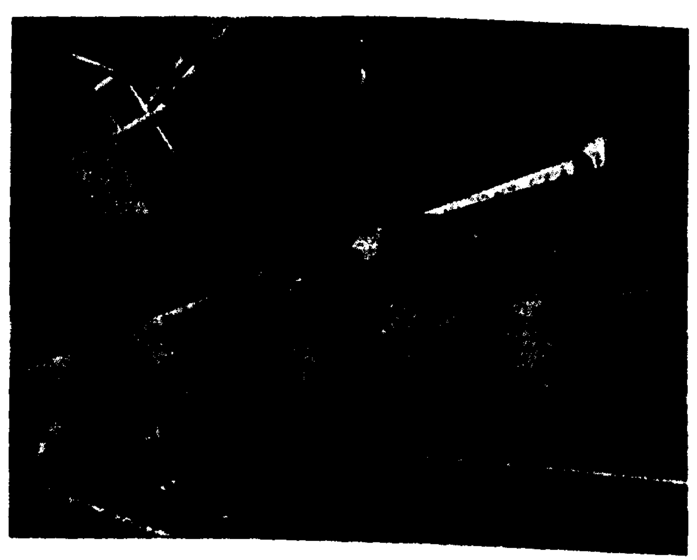
Perhaps the most important advantage of 'PLUTO' blue asbestos mattresses for railway locomotives is their long life. Blue asbestos is complete free from any tendency to lose fibre length or specific volume through vibration, and the blue asbestos cloth envelope is tough enough to survive frequent removal and refitting without damage. Acid fumes from combustion of coal have no corrosive effect on these mattresses, since they are made of 100% blue asbestos, and contain no organic matter whatsoever.

LIGHTNESS IN WEIGHT

Lightness in weight is of increasing importance to locomotive designers, with the increase of boiler size and operating speeds. No other type of insulation will give the same characteristics as 'PLUTO' asbestos mattresses at as low a weight. The normal weight of a ½ in. thick 'PLUTO' blue asbestos mattress is 24 oz. per sq. ft. (7 kgs. per sq. m.)

EASE OF FITTING, REMOVAL AND REFITTING

The fitting of 'PLUTO' mattresses is effected by means of brass hooks and brass or copper binding wire, and is a very simple operation which can be carried out by unskilled operatives. The mattresses are completely tailored to fit the individual boiler, fire box, etc. The toughness and durability of the blue asbestos cloth envelope makes removal and refitting an extremely simple operation. Boiler mattresses are generally supplied in one length to go round the boiler barrel in a convenient width for handling. Locomotive fire box mattresses are manufactured in the largest convenient pieces for fitting, with all cut-outs provided.



Smoke chutes at the B. R. locomotive sheds, Shoeburyness, made of 'PLUTO' blue asbestos cloth with the same characteristics as mattress cloth.

DETAILS REQUIRED WHEN ORDERING

It is usual to supply mattresses to insulate the whole of the locomotive boiler barrel, steam dome, the fire box, including the throat plate, and the steam cylinders. Mattresses are normally manufactured from templates, produced from detailed drawings supplied by the customer or consulting engineer, providing cut-outs for all fittings, stays, pipe connections, etc., so that no alterations are required at the time of fitting. Mattresses are normally marked alphabetically or numerically starting from the smoke box, and the marking normally appears on the developed drawings and on the mattresses.

Mattresses are made to the specification either of the operating company or of consulting engineers, and these specifications are adhered to whether the locomotive is built in their own workshops or by an outside contractor. Mattresses are provided with hooks already fitted, and with binding wire. They can be supplied with or without metal stools designed to hold the mattress slightly away from the boiler shell.

RAILWAY COMPANIES USING 'PLUTO' BLUE ASBESTOS MATTRESSES

'Pluto' blue asbestos mattresses have been in use for more than 50 years throughout British Railways, in many of the important Commonwealth countries including South Africa, India, Pakistan, East and West Africa, and in a large number of foreign countries notably in South America and Scandinavia.

The Railway Companies and the Consulting Engineers, who are familiar with the performance of these mattresses, continue to specify them in spite of exhaustive tests on competitive insulating materials.

'PLUTO' blue asbestos mattresses conform to current specifications of Railway Companies throughout the world.

USES, OTHER THAN FOR LOCOMOTIVES

The same characteristics as described above make 'PLUTO' blue asbestos mattresses a highly suitable type of flexible, removable insulation for marine boilers, small shell boilers, flanges, valve bodies, turbine casings, and any similar equipment, either in steam plant, or in any process plant where high temperatures exist. The navies of many of the maritime powers specify blue asbestos mattresses for removable insulation of all steam equipment.

RAILWAY STOCK FROM AUSTRALIA

Twelve diesel rail cars and 460 unassembled rail wagons have arrived from Australia for the Indian Railways.

They have now been unloaded from the chartered freighter "Belkarin" at Madras, where the rail wagons are being assembled and the rail cars prepared for service in the Indian Railways workshops.

Two Australian experts, Mr. S. Dick and Mr. I. Macfarlane, are in Madras to assist with this task.

The shipment is the second major delivery in a Colombo Plan project under which Australia is supplying India with 24 complete rail cars and 2,000 unassembled rail wagons.

The first major shipment— 5'0 rail wagons—reached India in July last year, and delivery has thus reached the half-way stage.

The other 12 rail cars and the rest of the rail wagons are expected to be delivered towards the middle of this year.

Each of the rail cars is valued at approximately £A60,000 (Rs. 6 lakhs).

The rail cars are of broad gauge, 72 feet long and 10½ feet wide, with seating for 82 passengers. They have double-end drivers controls, and each car is powered with two 200 B.H.P. Leyland horizontal diesel engines driving through fluid couplings and four-speed epicyclic gearboxes on the inner axle of each bogie. Their top speed is 80 m.p.h.

It is understood that the rail cars will be used on feeder services by Southern Railways.

This whole Colombo Plan project is designed to assist the development of the Indian railways system as part of the Second Five Year Plan. The total cost is approximately £A4 million (about Rs. 4 crores).

Designing Locomotives for a Market Having Widely Varying Needs

By D. R. Meier,
Locomotive and Car Equipment Department, General Electric Company, Erie, Pa.

INTRODUCTION

THE transportation system of a nation is as vital to its economic well-being as the circulation of blood is to the health of the human body. It is closely connected with every phase of economic life, from the production of raw materials to the distribution of finished products. It also provides the means for the free and rapid movement of people so essential to social, economic and political progress. Hence, it is evident that industrial and social advances can only be made when they are accompanied by a corresponding development of the transportation system.

As the economic progress of the Pan American nations continues, it is logical to expect that further improvements in transportation will take place. In many instances this will most likely include major emphasis on the improvement and expansion of railways. One aspect of such a program will be the replacement, where economically justified, of the steam locomotives with the diesel-electric or electric locomotive. Apparently the pattern will be generally similar to that followed in the United States over the past 15 years. Where oil supply is adequate, diesel-electric locomotives will probably be used. Their potential field is expanding with the oil developments now under way in several countries. In some localities the presence of abundant hydro-electric power may favour electrification for heavy-traffic main lines, with the diesel-electric locomotive serving the branch lines.

A valuable and illuminating comparison may be drawn between conditions existing in Pan American countries and those in the United States.

I. LOCOMOTIVE STANDARDIZATION IN THE UNITED STATES

The replacement of the "iron horse" with the diesel-electric locomotive is almost complete in the United States. This is clearly indicated by Chart I.

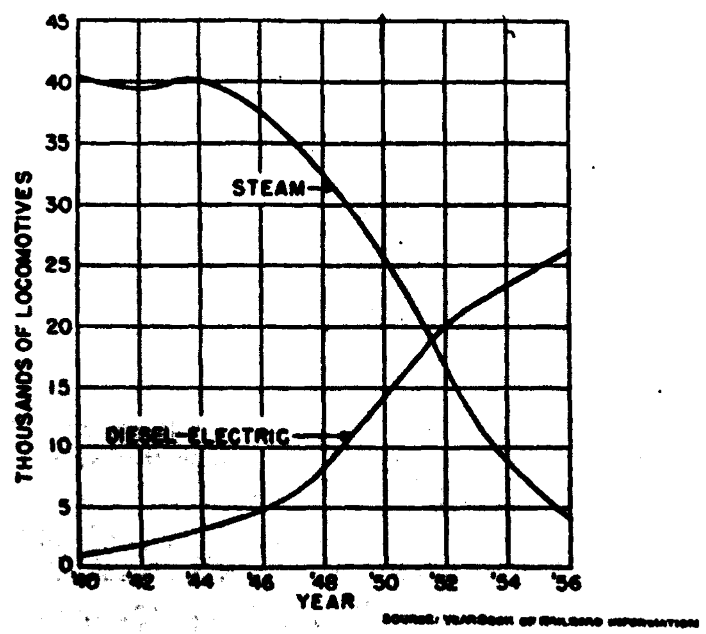


Chart 1. Progress of Diesel-electrification of the United States Railroads.

Although this shows an appreciable number of steam locomotives still in service at the beginning of 1957, they were confined largely to light traffic lines. A more accurate picture is given by locomotive performance statistics. During 1956 diesel-electric locomotives performed 88 per cent of the total freight gross ton-miles, 91 per cent of the total passenger-train car-miles, and 93 per cent of the total locomotive hours in yard switching service on the railways of the United States. (1)

This motive power revolution has been accomplished largely with well-developed standard types of locomotives. These all have the following outstanding features :

1. One standard gauge : 1435 mm. (56 1/2 in.)
2. Essentially the same clearance diagram, based on a cab width of 3048 mm. (10 ft.) and a height from rail to roof of 4420 mm. (14 ft. 6 in.)

(1) RAILWAY AGE, Vol. 142, No. 2, January 14, 1957, P. 103.

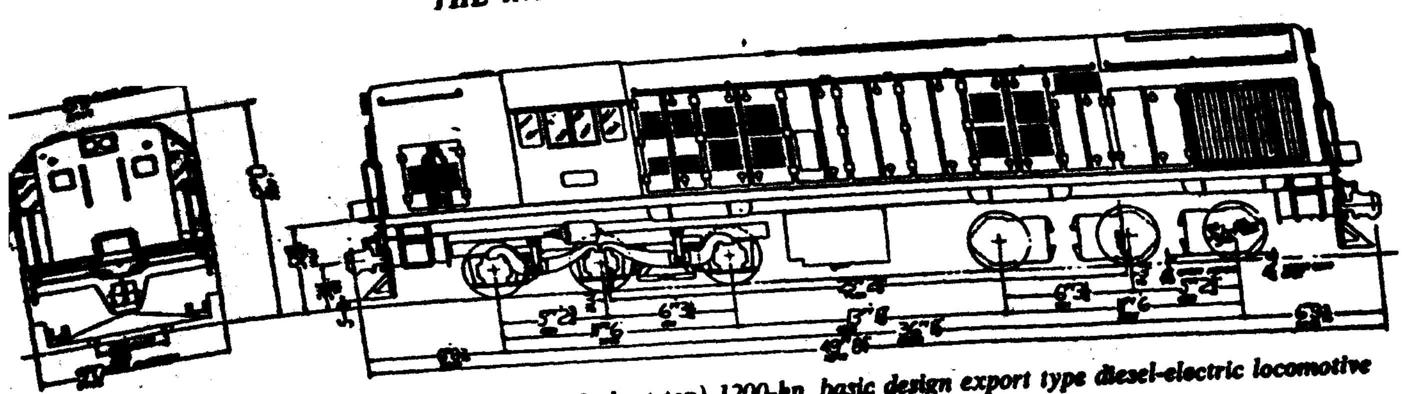


Fig. 1. Outline drawing of 81 metric ton (90 short ton) 1200-hp. basic design export type diesel-electric locomotive for Leopoldina Railway, Brazil.

Practically all axle loads within the range of 24.9 to 29.4 metric tons (55,000 to 65,000 lb.) per axle.

4. Diesel engine power output for traction ranging from 1500 to 2400 horsepower for road units, and 600 to 1200 horsepower for switching locomotives.

This standardization of motive power was possible because practically all railway track and structures in the United States are designed to permit operation of locomotives having the weights and dimensions given above. Both builders and users of locomotives reap benefits from so high a degree of standardization. These include lower first cost, shorter shipments from builders, lower maintenance costs, and simplification of servicing problems.

II. LOCOMOTIVES FOR PAN AMERICA

The standardization of locomotives for use in Pan America is a different problem. Here the favourable conditions existing in the United States are largely lacking. The data in Table I indicate some of the major differences encountered in permissible weight per axle, clearance limitations, coupler height and track gauge. This selection is representative and does not by any means present a complete picture of all the variations that must be dealt with.

Some railways may find it feasible to make changes in permanent way and structures to permit taking fuller advantage of standardization, although large-scale moves in this direction may be difficult. Understandably, in a preponderant majority of the situations encountered there will be a natural inclination to obtain locomotives to fit the railway rather than remake the railway to fit a standard locomotive.

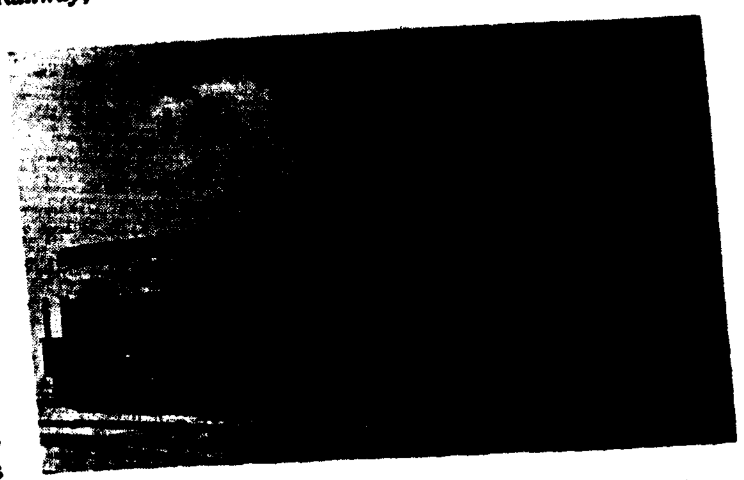


Fig. 2. 77 metric ton (85 short ton), 1000 mm. (39-⅜") gauge, 900-hp. basic design export diesel-electric locomotive for Chile.

Naturally, the locomotive purchased will represent some degree of compromise between complete individuality of design and complete standardization. Every step toward standardization that can reasonably be taken will prove beneficial to all concerned.

III. A "BASIC" LOCOMOTIVE DESIGN

Careful analysis of data accumulated from world-wide applications of electric and diesel-electric locomotives indicated the possibility of designing a basic locomotive type, from which variations could be built within certain limits.

In seeking to promote standardization in the diesel-electric locomotive field studies and experience indicate that best results can be achieved by creating a flexible basic locomotive design readily adaptable to the majority of the requirements encountered. Such a basic design should meet the following requirements:

Fig. 3. 92 metric ton (102 short ton), 1676 mm. (66") gauge, 1800-hp. basic design export type diesel-electric locomotive for the Argentine National Railways.

1. Adaptability to various gauges, the gauge requirement to be determined before manufacture.
2. Adaptability to various coupler heights and types.
3. Ability to meet composite clearance diagram which will permit operation on a majority of railroads.
4. Cab design to permit operation under a wide variety of conditions, such as switching and road service with either end leading. The cab that has found wide acceptance in the United States for this purpose is known as the "road-switcher" or "hood" type.
5. Overall design for minimum weight consistant with adequate mechanical strength.
6. Ability to maintain low weight per axle. The design will have greater adaptability if the superstructure is arranged so that it can accept either 2-axle or 3-axle trucks, as conditions require, without modification.
7. All weight to be on driving axles (no idle axles) in order to achieve maximum use of power and weight.
8. Utilization of standard electrical and mechanical components wherever possible.
9. Provision of certain options (with minimum disturbance of basic design) to suit differences in the requirements of individual railways. These options should include 2-station control, multiple-unit control, dynamic braking, train-heating steam generators, combined air and vacuum brake systems, and numerous other items.
10. Emphasis should be placed on a simplicity and reliability of components.

With these requirements in mind, a line of basic locomotives covering a range of 900 to 1808 hp. has been designed. Particulars of the design are given in Table II and one of the locomotives is illustrated in Fig. 1.

The engine used on these locomotives is manufactured by the Cooper-Bessemer Corporation, and is described in more detail in the section of this paper headed "Future Developments". The engine used on the 900-hp. locomotives is a 6-cylinder, in-line engine. The one used on the 1200-hp locomotive is a V-8, and that on the 1800-hp. locomotive is a V-12. The cylinder assembly, pistons, rings, valves, and many other components are common to all three engine sizes.

One traction motor model is used throughout the line on locomotives of meter gauge and larger. A modified version of the same motor is available for use on 914-mm. (36-inch) gauge locomotives.

The same generator is used on the 1200 and 1800-hp.

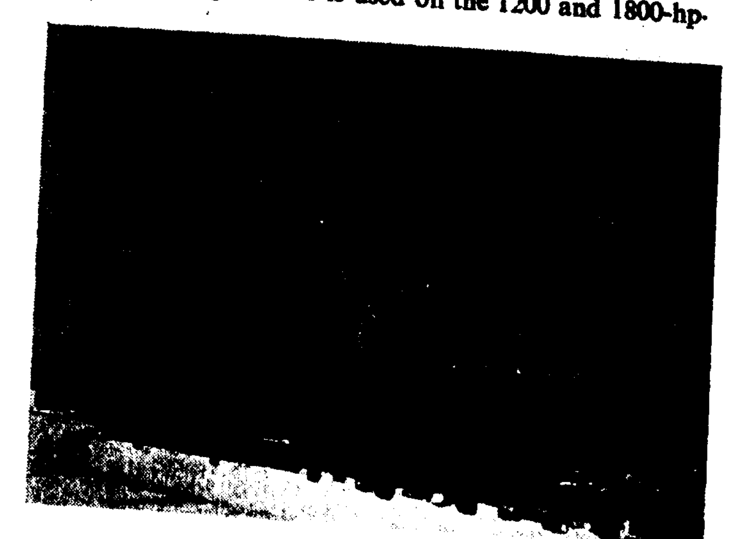


Fig. 4. 97 metric ton (107 short ton), 1000 mm. (39-⅜") gauge, 1600-hp. diesel-electric locomotive for Central of Brazil Railway.

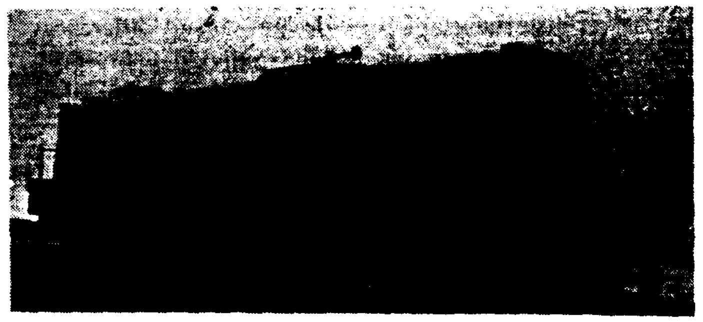


Fig. 5. 113 metric ton (125 short ton), 914-mm. (36") gauge, 1200-hp. diesel-electric locomotive for Colombian National Railways.

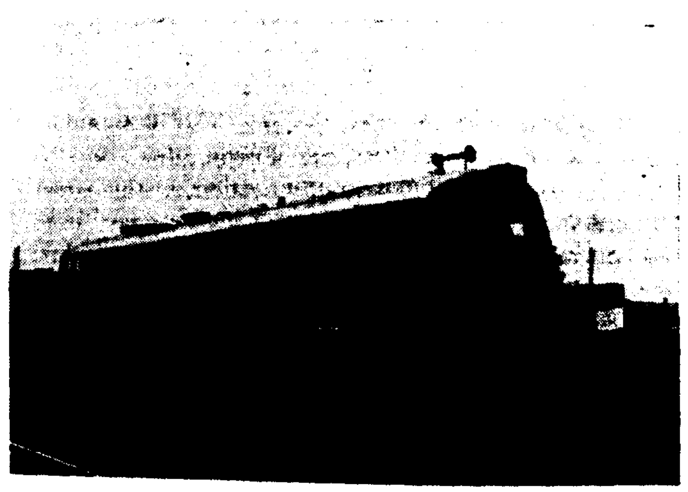


Fig. 6. 102 metric ton (112 short ton) 1434 mm. (56½") gauge, 1400-hp. diesel-electric locomotive for Uruguayan National Railways.

locomotives, and the same exciter is used throughout the entire line from 900 to 1800 horsepower.

Many components of the control system are common to all of the locomotives.

In addition to equipment, many of the mechanical components, such as journal bearings, wheels and axles, brake rigging, etc. are alike.

This extensive use of similar components is of great benefit, particularly to a railway requiring locomotives of several different ratings, because it simplifies the matter of stocking spare parts and of training both operators and maintenance men.

The outline of one of the locomotives in this line is shown in Fig. 1. This is the type being manufactured for the Leopoldina Railway of Brazil. A photograph of one of the locomotives built for the Chilean State Railways is shown in Fig. 2. They are equipped with straight and automatic air brakes.

The locomotives illustrated by Fig. 3 are presently under construction for the Argentine State Railways. These 1800-hp. locomotives are generally similar to the 900 and 1200-hp. units described above. They differ, however, in that each unit is equipped with a 75-kw auxiliary generator to provide power for passenger car heating.

Locomotives of this line will be applicable over a wide variety of railways with different permanent ways, structures and operating conditions. Because of their design and adaptability they can be used for all types of service, thus minimizing the total number of locomotives needed. The basic design also results in other economies stemming from standardization, such as reduced first cost, lower maintenance expense, and greater ease and economy of servicing.

IV. SPECIAL LOCOMOTIVES

Where standard designs cannot possibly be used, locomotives can be designed and built to meet any reasonable special condition encountered. Examples of such conditions are extreme limitations on weight per axle, specially restricted clearances, odd track gauge, unusual altitude conditions, coupler height outside the ordinary range, etc. Of course, departures from standard designs will be reflected in some increase in costs. Extra costs can, however, be minimized through cooperation of the builder and the railway in three ways.

1. Co-ordinating specifications and designs with a view to using standard electrical and mechanical components wherever they are acceptable. This will permit full advantage to be taken of reduced cost through repetitive manufacture and elimination of extra design work. It will also give the railway the advantage of a minimum number of special parts to operate and maintain.

2. Arranging, when possible, to build a quantity of locomotives at the same time. As is well known, design costs, starting costs, etc. are independent of the number of units produced. Hence, the greater the quantity of locomotives the less effect such costs have on the unit price.

3. Taking full advantage of well-known design principles to attain the special objectives required.

The following types of diesel-electric locomotives built for service in various parts of the world illustrate the wide variety of special conditions encountered and the means used to cope with them. Full particulars of each locomotive are given in Table III.

BRAZIL Forty, 1600-hp. locomotives were delivered to the Central Railways of Brazil in 1953 for service on their meter-gauge lines. The road-switcher type of cab, see Fig. 4, was used to give good visibility for operation with either end of the locomotive leading. The truck was designed with outside swing hangers to give better accessibility, and to permit a shorter truck of lower height with better performance on curves. The trucks are of fabricated construction.

This locomotive is notable for the fact that it provides a horsepower rating comparable to that used in United States main line railway service at a weight per axle of approximately 60 per cent of the value currently employed in the United States. The fact that these locomotives operate on meter-gauge lines also means that they had to be designed to meet much more restricted clearances than similar locomotives on standard gauge (1435 mm.) United States railroads.

COLOMBIA One of the five locomotives built for service on the National Railways of Colombia and shipped in 1952 is shown in Fig. 3. These locomotives were designed for operation over the line between Buenaventura and Cali where extreme conditions of curvature, and grades up to 4.5 per cent are encountered. Elevation varies from sea level at Buenaventura to 1581 meters (5,186 ft) at Crestegallo. To meet the required weight per axle and give the desired power in one unit, a C+B+C running gear arrangement giving 8 motored axles was used. The diesel engine was conservatively rated at 1200 horsepower input to the generator. The gauge of this locomotive is 914 mm. (36 in.)

Fig. 7. 104 metric ton (115 short ton) 1676 mm. (66") gauge, 1400 hp. diesel-electric locomotive for Argentine National Railways.

URUGUAY During 1954 twenty-seven double-end locomotives of the type shown in Fig. 6 were shipped to the Uruguayan State Railways. With the completion of this order Uruguay became the possessor of the most completely diesel-electrified railway system in the world.

These locomotives are for operation on 1435 mm. (56 1/2 in.) gauge track and are basically similar to the 20 placed in service in 1951 and 1952. The double-end box cab design was used to facilitate operation in either direction without turning the locomotive. This feature permits abandonment of outlying facilities and operation of the locomotives in round-trip service from a central maintenance and service point in Montevideo.

The low axle leading permitted by the permanent way required conservation of weight wherever possible. Accordingly the cab was so designed that the cab sides act as load-carrying members. This added materially to the stiffness of the platform and allowed an appreciable reduction in the size of its main members.

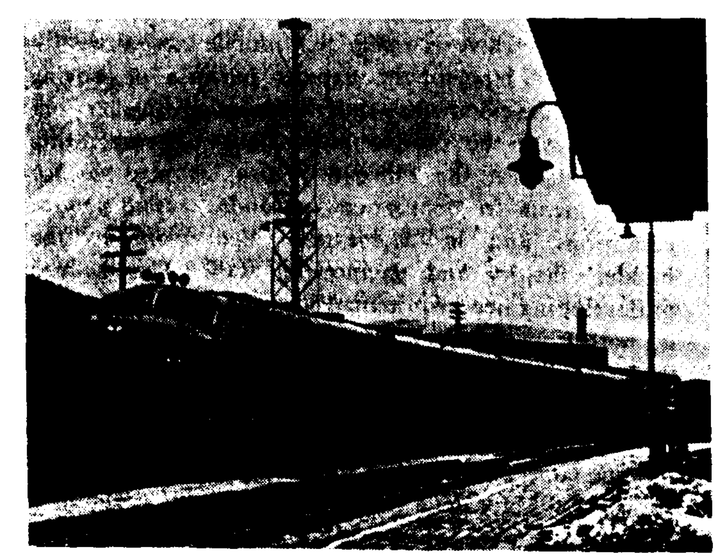


Fig. 8. 445 metric ton (490 short ton) 1434 mm. (56½") gauge, 6000 hp. 4-unit diesel-electric locomotive for test purposes in freight service on the Erie Railroad, U.S.A.

ARGENTINA Twenty-five passenger locomotives, as shown in Fig. 7, were placed in service by the Argentine State Railways in 1954. These are for use on the 1676 mm. (66 inch gauge lines, and resemble the locomotives designed for the Chilean State Railways. These wide-gauge locomotives are noteworthy in that they are of box-cab design, have six axles all motored, a V-12 engine and weigh only 17,300 kg. (38,000 lb.) per axle. These locomotives are equipped with multiple-unit control, allowing two units to be operated together as a double-ended locomotive of twice the capacity of one unit.

V. FUTURE DEVELOPMENTS

Developments are presently under way looking toward improvements in horsepower rating, reliability and maintenance of locomotives, whether of special or standard design. In 1954 the author's company constructed four diesel-electric locomotive units of the box-cab type for developmental test purposes. These consist of two leading or "A" units, one of the 1200-hp. and one of 1800-hp. and two trailing or "B" units, one of 1200-hp and one of 1800-hp. The 4-unit locomotive, shown in Fig. 8, has a total of 6000 horsepower for traction. Since September 1954 it has been operating in regular freight service on the Erie Railroad where it is assigned to runs 644 km. (400 miles) in length over a rolling profile with grades up to 1.0 per cent.

This locomotive is really a "mobile laboratory"—designed and built for the express purpose of proving out new developments and stimulating further improvements in the motive power field. The operating agreement with the railroad makes it possible for developments to be carried out under actual service conditions, and in a location convenient to the builder's factory and engineering staff. This method of developing new equipment has much to command it, both from the point of view of the builder and of the user alike.

Some conception of the thoroughness of the testing program can be gained from the fact that in the first 29 months of their operation these units accumulated a total of 1,665,000 kilometers (1,036,000 miles) or 490,000 kilometers (304,000 miles) for the 4-unit locomotive. This has been done in main-line freight service hauling trains of 2700 to 3600 metric tons (3000 to 4000 short tons) at speeds ranging up to 80 kph. (50 mph.). All regular maintenance and servicing are done by Erie Railroad personnel.

The diesel engines used in these units are of the V-type with cylinders having 228.6 mm. (9-in.) bore by 236.7 mm. (10 1/2-in.) stroke, manufactured by the Cooper-Bessemer Corporation of Mount Vernon, Ohio, U. S. A. These engines have hardened crankshafts and removable cylinder liners. Oil-bath air filters are provided for filtering engine air.

Dynamic braking circuits are arranged to provide greater maximum braking effort and better control of braking than has heretofore been available. The reaction of railroad operating personnel to this feature has been highly favourable.

In designing the units, advantage was taken of the principle of using cab sides to carry load. Moreover, the cab sides were fluted to give greater strength and rigidity. This construction will make possible the designing of box-type cabs having lighter weights.

As the equipment on these units is proved and evaluated much valuable information will be gained. It is confidently expected that the results will be many improvements generally applicable to locomotive design.

VI. CONCLUSION

The differences existing in permanent ways and structures of Pan American Railways preclude the possibility of locomotive standardization to the degree existing in the United States today. Nevertheless, the introduction of basic types of locomotives using standard components, which can be modified during construction to suit a variety of operating conditions, will be of great help to both builder and user. Such basic type locomotives offer advantages from the standpoint of first cost, maintenance and service charges, and procurement time.

New developments under way will be of advantage in the design of all types of locomotives. They will make possible increased ratings, increased reliability, and decreased maintenance and operating costs.

TABLE I

Summary of Differences in Major Locomotive Design Constants on Pan American Railways

1.	Track gauge	—	914 mm. (36") to 1676 mm. (66")
2.	Coupler height	—	750 mm. (29 1/2") to 1029 mm. (40 1/2")
3.	Overall height	—	3683 mm. (12′ 1 1/8″) to 4080 mm. (13′4 5/8″)
4.	Overall width	—	2642 mm. (8′ 8″) to 3073 mm. (10′ 1″)
5.	Length over Couplers	—	15011 mm. (49′ 3″) to 17323 mm. (56′ 10″)
6.	Min. wgt. per axle	—	11.9 mt. (26,400 lb.) to 18.3 (40,500 lb.)
7.	Brakes	—	Independent and automatic air on locomotive and train, independent air on locomotive and vacuum on train, or combined independent and automatic and vacuum brakes.
			Dynamic braking may be added to any of the above.
8.	Couplers and Draft Gear	—	Either American or European type, or "multi" coupler arrangement.
9.	Altitudes	—	From sea level to 4400 m. (14,000 ft.)
10.	Ambient temperatures	—	up to 49°C (120°F) maximum.

TABLE II

Principal Data on Standard Export Diesel-Electric Locomotive Line

HP for Traction	cv hp	912* 900*	912* 900*	1216* 1200*	1216* 1200*	1824* 1800*
Cab Design				Road Switcher		
Wheel arrangement		B-B	C-C	B-B	C-C	C-C
Total weight	m. t. s. t.	67.2 74.2	77.0 85.0	70.1 77.2	79.6 87.8	92.1 101.5
Wgt. per Axle	m. t. s. t.	16.8 18.6	12.8 14.2	17.5 19.3	13.3 14.6	15.3 16.9
Height & Width	mm ft.			3658×2743 12×9		
Minimum Gauge	mm in.			1000 39 3/8		
Diesel engine		FW-6	FW-6	FV-8	FV8	FV-12
Traction generator		1-GT599	1-GT-599	1-GT581	1-GT581	1-GT581
Traction motors		4-GE761	6-GE761	4-GE761	6-GE761	6-GE761
Wheel diameter	mm in.			914 36		
Nominal Max. Speed	kph mph			96.5 60		
Fuel capacity	lit. gal.	3028 800	3028 800	3028 800	3028 800	3407 900

*Net input to generator for traction.

TABLE III

Comparison of Principal Features of Diesel-Electric Locomotives Designed for Special Applications on Pan American Railways

Customer	Engine	HP. to Generator	Wheel Arrangement	Total Weight m. t. (s. t.)	Weight per Axle m. t. (s. t.)	Gauge mm. (in.)	Overall Width mm. (ft.-in.)	Height over Roof mm. (ft.-in.)	Wheel Diameter mm. (in.)	Minimum Curve m. (ft.)	Tractive Effort (Continuous) kg. (lb.)	Maximum Speed kph. (mph.)	Dynamic Braking*	Train Brakes*
Central of Brazil Ry.	V12	1600	C-C	97 (107)	16.2 (17.8)	1000 (39 3/8)	2743 (9'0")	4064 (13'4")	914 (36)	70.1 (230)	20,140 44,400	96.5 (60.0)	Yes	Air
Colombian National Rys.	V12	1200	C+B+C	113 (125)	14.1 (15.6)	914 (36)	2743 (9'0")	3810 (12'6")	838 (33)	70.1 (230)	17,070 37,600	64.4 (40.0)	Yes	Air
Uruguayan National Rys.	V12	1400	C-C	102 (112)	16.9 (18.6)	1435 (56 1/2)	3073 (10'1")	4051 (13' 3 1/2")	1016 (40)	82.4 (270)	15,880 35,200	96.5 (60.0)	No	Vac.
Argentine National Rys.	V12	1400	C-C	104 (115)	17.3 (19.1)	1676 (66)	3073 (10'1")	4080 (13'4 5/8")	1016 (40)	70.1 (270)	15,389 36,100	120.8 (75.0)	No	Vac.

*All locomotives are equipped with independent air brakes regardless of type of train brake.

ABOLITION OF SECOND CLASS

Second Class accommodation in long-distance trains would be abolished only after sufficient sleeping accommodation had been provided for Third Class passengers, Shri Shah Nawaz Khan, Deputy Minister for Railways said in the Lok Sabha.

The Deputy Minister replying to Shri T. B. Vithal Rao, said that Second Class had already been abolished on short branch-line sections and on the Suburban sections of Calcutta and Madras. No time limit has been fixed for its total abolition.

Asked why Second Class had still not been abolished in long-distance trains, Shri Shah Nawaz Khan said that this class was still very popular in long-distance trains.

The Railways, he said, were trying to provide sleeping accommodation in Third Class compartments and when they were satisfied that there was sufficient accommodation and passengers would not be put to any great inconvenience, Second Class would be abolished totally.

In reply to another question the Deputy Minister said that two types of sleeping coaches were on trial. As soon as the type of sleeping coach was decided, construction of additional third class sleeping coaches would be taken in hand, he said.

* * *

EIGHTH RAILWAY ZONE

The Government of India have decided that the eighth railway zone to be created by splitting the existing North-Eastern Railway, should be known as the North-East Frontier Railway (N.F.R., for short), and it will have its headquarters at Pandu. The remaining portion of the North Eastern Railway will continue to be known by its present name with headquarters as at present, at Gorakhpur.

Electrification — Only Answer to Calcutta's Problems

By B. C. Khanna,
Officer on Special Duty (Transportation), Calcutta Electrification Project, Eastern Railway

Electrification was the only answer to the problem posed by Calcutta area's growing traffic demands, and the Railway Board sanctioned stage one of the electrification programme in June 1954. This is now nearly complete. The author explains the salient features of the project report which covered several stages of electrification in India's eastern region.

THE Railway Board appointed a Project Officer in July, 1953 to prepare in detail a scheme for the application of electric traction on the Calcutta Railways system, which would extend later up to the coalfields in the Asansol-Dhanbad area, to Tatanagar on the South Eastern Railway and up to the Pakistan border on the east. Proposals were also invited for implementing the suggestions made earlier by a committee appointed by the Government of India to investigate the feasibility of running suburban passenger train services over the Port Commissioners' railway lines in Calcutta.

The electrification of a railway system involves a huge capital outlay and as only financial considerations had to decide in the previous investigations whether electrification of the suburban sections of the Calcutta area was justified or not, none of the important schemes suggested by them could materialise during the last 43 years.

SUBURBAN TRAFFIC AFTER WAR

The conditions of suburban traffic in the Calcutta area after World War II, however, completely changed and it became inevitable to spend large sums of money in the course of a few years to give Calcutta a system of transport commensurate with its importance and position in the life of the country. Whatever be the political and constitutional changes in and around us, the development of Calcutta area and its suburbs, on account of its commerce, its industries, its financial position, its proximity to the principal mineral and agricultural resources for local consumption and for export and its possession of a great port, has become absolutely inevitable and the vast expenditure required for the adoption of measures to improve its transport facilities has to be incurred.

The Project Officer started work with his team in August 1953 and submitted a preliminary report for Calcutta's suburdan electrification in early 1954. The final report was submitted in June, 1956. The order in which it was suggested the different sections should be brought within the overall scheme of suburban electrification was:

STAGE I

Howrah-Burdwan via Bandel
Lillooah Sorting Yard
Sheoraphuli-Tarakeswar

STAGE II

Bally-Saktigarh (H. B. Chord)
Calcutta Chord Link
Bandel-Naihati
Sealdah-Kalyani
Dum Dum-Chitpur
Kakurgachi-Chord
Ballygunge-Budge Budge
Majherat-East and West Dock Jn.
Sealdah-Ballygunge

STAGE III

Circular Railway
Dum Dum to Hastings (Phase I)
Hastings to Majherat (Phase II)

STAGE IV

Kalyani-Ranaghat
Ranaghat-Krishnagar City
Ranaghat-Santipur
Dum Dum-Bongaon
Ballygunge-Baruipur

STAGE V

Howrah-Khargpur including
Santragachi to Shalimar

STAGE VI

Baruipur-Diamond Harbour
Baruipur-Lakshikantapur
Sonarpur-Canning.

DENSITY OF SUBURBAN TRAFFIC

The average daily density of suburban traffic on the various sections from the terminal stations of Howrah and Sealdah was found on investigations as under:

(Figures in thousands)

Section	Average density per mile within 15 miles	Average density per mile between 15 & 24 miles	Average density per mile beyond 24 miles
Howrah-Burdwan (Main Line)	44.5	15.0	3.5
Sheoraphuli-Tarakeswar	5.5	3.8	3.0
Calcutta Chord Railway	3.3	—	—
Howrah-Burdwan (Chord)	9.8	4.6	3.2
Bandel-Naihati Branch	2.3	—	—
Sealdah-Ranaghat	45.0	23.8	10.0
Dum Dum-Bongaon	9.0	8.0	3.0
Calcutta (South)-Baruipur	25.5	—	—
Baruipur-Lakshmikantapur	—	2.6	1.0
Baruipur-Diamond Harbour	—	5.1	2.7
Sonarpur-Canning	3.8	2.5	—
Ballygunge-Budge Budge	3.0	—	—
Ranaghat-Santipur	—	—	1.5
Ranaghat-Krishnagar	—	—	2.0
Howrah-Panchkura (S. E. Rly.)	18.5	12.1	4.0

FIRST STAGE OF ELECTRIFICATION

The volume of suburban traffic over the Howrah-Burdwan section (main line) is slightly lower than over the Sealdah Ranaghat section. We have, however, a large number of through passenger trains and goods trains on the Howrah-Burdwan (main line) section and the anticipated increase in both the passenger and the goods traffic on the section is also high. The through traffic for the Calcutta area is mainly received from and *via* Burdwan and it was, therefore, considered desirable to start electrification from Burdwan and to extend it later to the Sealdah Division subject to availability of funds.

The Tarakeswar Branch was included in the first stage of the suburban electrification primarily because of its location on the Howrah-Burdwan (main line) as also because its terminal station is only 35½ miles from Calcutta thus offering good prospects of development as a result of electrification. It was also not desirable to put Tarakeswar passengers to the inconvenience of changing trains at Sheoraphuli for their short journey of 14 miles to Howrah. The release of the rolling stock from this branch after the introduction of the electric multiple unit trains was the other important economic factor considered.

SEALDAH-KALYANI SECTION

The electrification of the Sealdah-Kalyani section was included in the second stage, comprising Burdwan to Belur *via* Howrah-Burdwan Chord, Docks to Dankuni, Sealdah-Budge Budge and Bandel to Naihati.

The extension to Kalyani was considered necessary as the substation which was to feed a section of the overhead lines near Naihati could be located at Kalyani for maximum overall efficiency. This would also help the new township of Kalyani sponsored by the West Bengal Government.

BANDEL-NAIHATI SECTION

The Bandel-Naihati section deals with about 12 goods trains each way in addition to a similar number of passenger trains in each direction. If the electrification of the section was to be taken up immediately after the electrification of Howrah-Burdwan (main line), it would not be necessary to terminate the goods trains from Burdwan at Bandel and rearrange them with fresh engine and crew. The saving of steam locomotives and the existing passenger coaches after procurement of only two units of electric multiple stock also weighed in favour of the inclusion of Bandel-Naihati for electrification along with, or soon after, Phase I of the electrification scheme.

BUDGE BUDGE BRANCH

This branch carries very heavy goods traffic offered by the Calcutta Port as also the mineral oil from Budge Budge, in addition to no less passenger traffic.

STAGE IV OF ELECTRIFICATION

The electrification of the sections Dum Dum-Bongaon, Kalyani-Ranaghat, Ranaghat-Krishnagar, Ranaghat-Santipur and Ballygunge-Baruipur was proposed after the Circular Railway which was included in stage III.

CIRCULAR RAILWAY

The Project Officer considered the inclusion of the Circular Railway in stage III necessary as electrification of the suburban sections alone would provide only a partial relief to the travelling public unless the different existing routes were linked up not only with the approaches and surroundings of Calcutta but also with as many focal points as possible in the city to and from which passenger traffic flows daily into and away from Calcutta.

A passenger has to come either to Howrah or Sealdah station and find his way by bus, tram or taxi to his place of business, residence, shopping or recreational and is thus forced to supplement some other mode of transport for completing his journey to destination. The people living on the north of Calcutta, on both the sides of the river Hooghly, have no direct approach by rail to any part of the city along the river from Chitpur to Strand Road, Fairlie Place, Dalhousie Square, Outramghat or Hastings. Similarly, those who live in the southern suburb or further out on the Budge Budge or Diamond Harbour section and have their place of work in the Kidderpore Dock area or in the business areas of Calcutta, have no direct approach to their destination by rail.

The Project Officer did not find it necessary to suggest any major changes in the alignment or in other details suggested by the committee referred to above, the following guiding principles being kept in view:

(a) that no alignment should be accepted which would in any way interfere with the facilities for the handling of the shippings at the docks or with the free movement of goods to and from the Port Commissioner's yards and the warehouses and docks.

(b) that in the interests of the foreshore, the minimum of interference should be caused to the movement of rail traffic which a modern city requires.

HOWRAH-KHARGPUR SECTION

The suburban traffic of the Howrah-Khargpur section is quite heavy and the density of through passenger and goods traffic on this section is also very heavy. From the financial point of view, I think, electrification of this section should take precedence over the electrification of some of the single line sections of the Eastern Railway suburban area.

A feature of suburban train working is that there is heavy traffic for about two hours in the morning and two or three hours in the evening and there is comparatively lighter traffic during the remaining hours of the day. There is no suburban traffic altogether for about five to six hours during the night. Suburban traffic yields less revenue per passenger mile as most of the suburban passengers utilise the concession offered by monthly tickets. The cost of working purely suburban trains per thousand gross ton miles is also higher on account of the high acceleration required and the frequent stoppages of suburban trains as compared to other main line passenger or goods trains.

On the Sealdah division of the Eastern Railway, suburban traffic is carried on several long lengths of single lines but some of these sections do not have any goods traffic worth mentioning. It was, therefore, suggested that electric traction be applied to all the train services in the suburban area, including the through passenger and goods services and the slack periods of the night should be taken advantage of for running goods or through passenger trains.

E. M. U. STOCK SUGGESTED

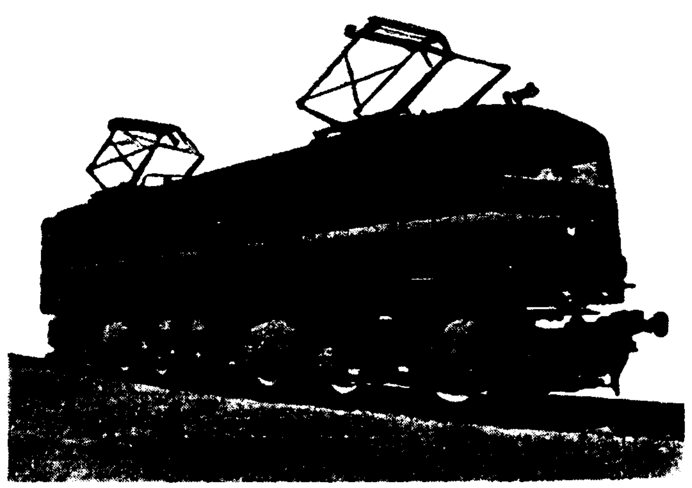
In the scheme of suburban electrification it was proposed that all the suburban trains be run with electric multiple unit stock, as in Bombay and other places, and the goods and passengers trains be hauled by dual purpose electric locomotives.

A multiple unit train is a train in which the motive power is distributed over a number of carriage axles, instead of being concentrated in a locomotive, and controlled by means of power-operated switches from a remotely situated driving equipment in a driver's cab at the leading end of the train. It may be composed of any suitable proportions of motored and non-motored cars. For Calcutta suburban electrification the three coach multiple unit stock has been recommended which will permit a long train of

(Continued on page 46)

One-Piece Cast Steel Bogies for Rolling Stock

MORE and more Railways throughout the world are changing over to cast steel one-piece bogies for all types of rolling stock including diesel, diesel electric and straight electric locomotives, passenger and multiple unit stock, and heavy freight-carrying vehicles. English Steel Castings Corporation Limited of Sheffield, England, are currently producing the world famous 'Commonwealth' bogies designed by General Steel Castings Corporation Limited of Granite City, Illinois, U. S. A. English Steel Castings Corporation have installed at considerable expense, the most modern foundry and machine shop equipment at their Sheffield works, to cope with the ever increasing demands for these specialty Castings.



3820 hp. 0–6 6–0 Electric Locomotive built by Metropolitan-Vickers—Beyer Peacock Ltd., England for New South Wales Government Railways fitted with Cast Steel Driving Truck Beds supplied by English Steel Castings Corporation Ltd.

There are many advantages to be gained by the use of one-piece cast steel bogies, not the least of these being that they are designed to provide exceptional strength with minimum weight. In a one-piece cast steel bogie frame, the design engineers can distribute the metal in a homogeneous structure as desired, changing thickness as required for the loads without abrupt changes of section or sharp projections and thus maintain uniform stresses throughout. In consequence those stress concentrations common in fabricated bogies which frequently result in fatigue failures, are avoided.

Since one-piece cast steel bogies are also completely free from joints, they can be designed of lighter weight than fabricated bogies of comparable strength.

Bogie frames in operation are subjected to many hundreds of stress reversals each day, particularly as all the vital forces for driving and stopping must be transmitted through the bogie frame; it is also the bogie which must absorb the substantial loads imposed by track irregularities and curving forces. All these factors are taken into consideration by the highly skilled and experienced engineers who design 'Commonwealth' one-piece cast steel bogies as manufactured by English Steel Castings Corporation Limited.

The integral horn guides and correct radii at cross members and other points are only practical in a casting, thus ensuring permanent alignment and keeping the bogie frame square at all times. This

(Continued from page 45)

six, nine or twelve coaches for the peak periods and the formation can be shortened to three or six coaches only during the slack periods of traffic.

As for the employment of the dual purpose electric locomotives, a large amount of saving can be effected by curtailing the periods of 'lie over' of an engine in order to get a return load.

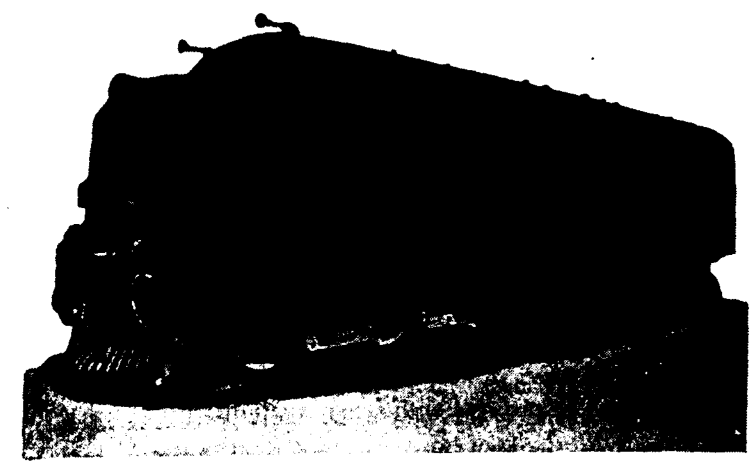
FIRST STAGE OVER

The electrification of the sections included in Phase I of the scheme, which was ordered by the Railway Board in June, 1954 is nearly complete except for the fact that for some time passengers will not have the advantage of the electric multiple unit stock, the supply of which has been delayed on account of unforeseen reasons.

The electrification of the sections included in stage II, IV, V and VI as stated above has also been included in the second Five Year Plan and the civil engineering works for the scheme have been taken in hand. It is hoped that sanction for the proposed Circular Railway for Calcutta which was included in stage III of the electrification will not be far behind.

6 wheel Cast Steel Driving Truck Bed for New South Wales Government Railways 3820 hp. 0–6 6–0 Electric Locomotives.
Approximate weight 8 tons 5 cwts. Length 25' 0" Width 8' 9"

"Commonwealth" 6 wheel Cast Steel Bogie Frame for New Zealand Government Railways 750 hp. Diesel Electric Locomotives AIA–AIA Type
Approximate weight 2 tons. 5 cwts. Length 16' 9" Width 7' 2"



750 hp. AIA–AIA Diesel Electric Locomotive built by Robert Stephenson & Hawthorns Ltd., England for New Zealand Government Railways. Fitted with Commonwealth Cast Steel bogies supplied by English Steel Castings Corporation Ltd.

results in the proper functioning of wheels, axles and roller bearings with improved riding and reduced maintenance.

The cast steel bogies produced by English Steel Castings Corporation Limited are manufactured of a tough ductile steel and are extremely resistant to corrosion and can be expected to outlast the life of the locomotive.

The frame castings are supplied completely machined and drilled with parts fitted by English Steel Castings Corporation Limited, such as bushings, hornguide liners, wearing plates, hornclips, etc., thus requiring only assembly work to be carried out by the builder.

'Commonwealth' bogies as manufactured by English Steel Castings Corporation Limited are usually designed to be of the equalised type by the use of compensating beams which quickly distribute the loads throughout the bogie on rough track, reducing overloads on journal bearings and minimising weight transfer which contributes to wheel slippage, highly undesirable on locomotives. Swing hanger motion improves riding and reduces flange wear.

'Commonwealth' bogies have been supplied either by English Steel Castings Corporation Limited or General Steel Castings Corporation for steam, diesel electric, and electric locomotives, also for Multiple Unit and passenger stock in the following countries:—

Eire, South Africa, French North Africa, Spain, Algeria, Belgian Congo, Jamaica, Thailand, East Africa, Portugal, Australia, Rhodesia, New Zealand, Great Britain, Mexico, Uruguay, Argentine, France, Pakistan, Venezuela, Brazil, America, Canada.

Electric Trains will aid Calcutta Suburban Development

By N. Padmanabhan,
Deputy Chief Electrical Engineer,
Electrification Project, Eastern Railway

As against the existing 35 trains each way running daily on the Howrah-Bandel and Howrah-Tarakeshwar sections, plans are in hand, after the introduction of electric trains, to provide ultimately a daily service of 90 trains each way. Electrification will also help in relieving congestion in Calcutta city by dispersal of the population to the Suburbs.

WITH the dawn of the era of industrial development the tendency all over the world is for the population to leave the village and drift into the city. Probably this is so because it is possible to earn one's livelihood more easily in a city, particularly in an industrial one, than in a village where one has to depend for one's living on the vagaries of the monsoon. In addition, the villager enjoys the bustle, the sights and the sounds of the town. As for the middle class, they have firmly entrenched themselves in the cities conscious of the advantages of corporate life and the varied amenities which city life provides.

Thus cities have grown leading to the inevitable congestion which is rendered all the more acute by the continual growth of population. Calcutta is no exception to this. Its large port, a haven for shipping all the year round, its local market of great and growing importance, a vast trading hinterland, its vicinity to the coal and mineral belt, availability of cheap electric power, and the two railways which provide direct and economic access to all parts of India have all paved the way to its growth and development. Also, the problem of congestion is aggravated by the large influx of displaced persons as a result of Partition.

In order to ease the congestion and provide healthier and better living conditions, the development of suburbs offers the best solution. The opening up of large suburban areas, however, depends on the improvement and extension of road and rail transport. The average city worker likes to live in the quiet of the suburbs away from his spot of work and other amenities of the city so long as he has quick and easy access to them.

HELPING POPULATION DISPERSAL

Before the city dweller is persuaded to become a suburban dweller, he would like to be assured of a transport system which would provide service at frequent intervals and which would carry him safe to his destination in comfort, at a high speed and at a reasonable fare. These requirements could be met only by the introduction of electric trains. A large scale development of suburbs in almost all the large cities of the world has become possible only after electric train services were introduced.

The London Underground, the Paris Metro and the New York Subway have helped the population of these cities to disperse over large areas. Nearer at home, the electric trains at Bombay and Madras have proved this beyond doubt. It is expected that the introduction of electric trains in Calcutta would also accentuate the development of its suburbs and help to mitigate the problem of congestion. The electrification of the suburban section from Howrah to Burdwan which has been taken up in the first phase of electrification around Calcutta would provide a degree of improvement in the suburban train service which would not be possible with steam traction.

For a good suburban service, which means a smooth and efficient working of trains at high speeds and at frequent intervals, the trains should originate in areas having light traffic density, run through areas of high traffic density and terminate in areas having light traffic density. Under such conditions the problem of coping with a large volume of traffic is considerably eased because it is not coupled with the problem of handling and reversal of trains. The problems of terminal working therefore cease to exist. The success of the London Underground or the Paris Metro is in no small measure due to this particular feature.

PROBLEM OF TERMINAL WORKING

In the case of the electrification of the Howrah-Bandel section, the problems of terminal working loom large. Terminal working at Howrah station and its network of lines with steam traction is complicated and no more trains can be introduced without adding greatly to the existing facilities. To do this would, in turn, add considerably to the complication of the working of such a large terminus. The necessity of obtaining relief before additional trains can be introduced is of paramount importance. It was out of the sheer necessity to obtain relief at the terminii that the ex-Southern Railway authorities in U. K. had to go forward with an extensive programme of electrification, which was crowned with success.

With steam traction, complication is caused by the multiple movement of steam engines to and from the shed, empty rakes and passenger trains. As each engine, locked up at the buffer stop ends of the bay platforms is released, there is additional occupation of the station running lines for both the outgoing and the incoming trains. The light engine working and the extra occupation of lines hampers the efficient and smooth working of the terminus. The abolition of light engine movement would undoubtedly provide great relief which would consequently increase the working capacity of the station.

It would be of interest to understand this, so that we may appreciate it in full measure. When hauled by a steam engine, movements must take place somewhat along the following lines. First, the train runs up to a platform, the engine being temporarily imprisoned at the buffer stop end of the line, unless a cross-over is available to the adjacent line and the adjacent line is clear for the movement of this engine. Then a fresh engine has to be brought to the front end of the train, blocking the section of the line from the engine shed up to the platform, with all the necessary setting of points and block signalling operations. After the train is taken away the imprisoned engine has to be got away to the engine shed or to a station refuge siding causing a further block of the approach lines, which would be fouled as it is brought out.

MULTIPLE-UNIT WORKING

With electric traction under the system known in technical parlance as "multiple-unit" working, the train can be worked with equal ease in either direction, backwards or forwards, as may be required. By this system of train working instead of merely changing form a steam engine to an electric locomotive hauling a train from one end of it, the train is composed of units, each with its own motive power unit made up of electric motors, capable of being worked from either end, from driving compartments, fitted with devices to control the motors. The number of units of which a train is made could be adapted to suit the needs of traffic.

Under electric multiple-unit working, the train coming into a dead-end platform may work out in the reverse direction within a few minutes of its arrival, which is usually limited by the time taken by the guard and the driver known as the motorman to exchange positions. Further, when the driver enters his cab, there is no steam pressure to be built, no water to be pumped into the boiler, no fire to be attended to. The power produced at Bokaro or Maithon is all in readiness to run the train at a movement of the control lever. It is this simplicity of reversal under electric train working which is the key movement in effecting improvement in station working.

The immense degree of relief afforded by the easy reversal of electric trains, coupled with automatic signalling enables a high frequency of services to be established. At Howrah, with the facilities that have been provided in the Howrah-Bandel section, it would be possible to run electric trains at intervals of five minutes. Plans are on hand to run ultimately a daily service of about 90 suburban trains each way in place the existing 35 trains each way, in the section Howrah to Bandel and Howrah to Tarakeswar.

MORE PASSENGER COMFORT

The suburban dweller usually measures the distance from his residence to the place of work or entertainment in terms of minutes and not in miles. For this he needs transport which would transport him quickly, thereby saving time. Electric trains alone would meet his needs satisfactorily. The acceleration, being far higher than that of any other form of traction, enables the electric trains to get away quickly and cover distances between frequent stops in the shortest possible time.

The electric trains for Calcutta would pick up a speed of 1.1 miles per hour in every second and before the tail end of the train clears the platform it would have attained a speed of over 30 miles per hour.

Some of the features of the specially built electric multiple-unit trains which have been ordered for Calcutta are of particular interest because they contribute to passenger comfort. Unlike ordinary steam stock whose width is 10′ or 10′—8″, the electric stock is specially designed for a width of 12′ and therefore capable of accommodating a much larger number of passengers. The open type of carriage with central gangway has been adopted in preference to smaller compartments to enable an even distribution of passengers throughout the coach. Wide double-sliding doors provide easy entrance and exit which would facilitate the entraining and detraining of large crowds in a short space of time.

It is an established fact that a large percentage of the passengers cannot have sitting accommodation and have to travel standing during the morning and evening rush hours. The compartments have, therefore, to be designed for maximum standing comfort. Strap hanging, up-right pillars and innumerable little devices are provided to make the rush hour travel less irksome.

In the suburban electric trains for Calcutta on order, seating accommodation for approximately 100 passengers per coach is being provided. Normally a coach could accommodate an additional 100 standing passengers and during rush hours this number could be doubled.

Initially, electrically operated trains hauled by locomotives are being brought into use. Though this would contribute to better and cleaner travel, the full benefits which electric traction would confer on the community would only be realised after the introduction of the electric multiple-unit trains.

CZECH METALLURGICAL PLANT FOR INDIA

Czechoslovakia is to export a complete metallurgical engineering plant to India, the first of its kind here. The plant will be built at Ranchi and will supply forgings and castings to a heavy engineering plant with a capacity of 45,000 tons of engineering products yearly to be constructed in the same area by the Russians. The maximum weight of the castings will be 100 tons. The plant is the biggest Czechoslovak single delivery to India yet, and ranks amongst the largest ever exported by Czechoslovakia. It will go into operation in two stages between 1961 and 1964. Agreement on the plant was reached in Czechoslovak-Indian talks in New Delhi on January 3.

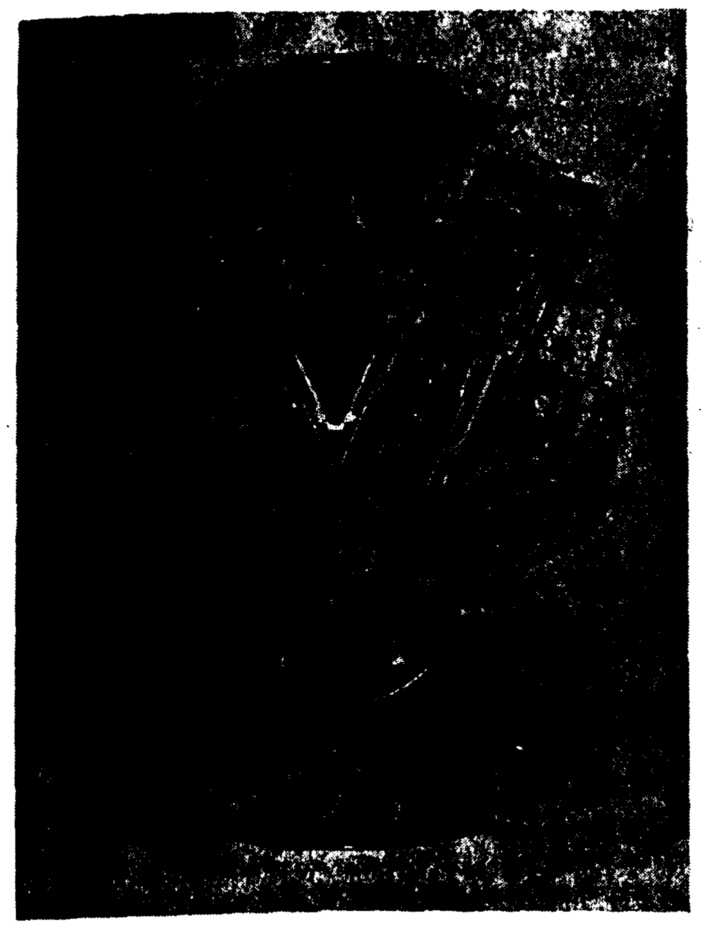
ALCO Products — A Pioneer in Diesel Locomotive Development

(Exclusive to "The Indian Railway Engineer")

THE history of railroad locomotive development is literally loaded with accounts of technological improvements that are today spreading the diesel-electric locomotive over the routes of rail carriers throughout the world.

A leader in developing first the steam locomotive and, more recently, diesel-electric motive power, is ALCO Products, Inc., the former American Locomotive Company. Once almost exclusively a builder of locomotives, ALCO is now widely diversified and active in more than 11 other major markets.

The company is a pioneer in the application of nuclear energy as a source of electric power, and it is a key supplier of components to the United States missile program.



Cutaway of ALCO's Vee-type Model 251 diesel engine. This engine is built in the 12 and 16-cylinder sizes, with horsepowers of 1800 and 2400 respectively. A 6-cylinder, in-line engine also is built in the same series.

These ALCO DL-430, 900-hp. switching locomotives were among units built for service in Mexico. Suitable for light passenger and branch-line freight service as well as switching, these units offer low first cost and economical operation.

But the history of ALCO is in large measure the history of locomotives and diesel engines. The company and its predecessors have been in that business—with its attendant need for constantly improving technology—since 1837. ALCO pioneered the steam locomotive and later built such famed "steamers" as the "Hiawatha," "Niagara," and "Big Boy"—all milestones in the steam-locomotive lore of America.

DIESEL-ELECTRIC DEVELOPMENT

Immediately after World War II, the company embarked on a program of volume production of diesel locomotives for U. S. and overseas railroads, so that today nearly 8,000 units with ALCO nameplates are in service throughout the world. Today, ALCO ranks as the leading exporter of diesel locomotives.

In the 10 years since volume production of diesels was begun at Schenectady, New York, the company's engineers and technicians have contributed many significant advances to the complex science of diesel-locomotive fabrication.

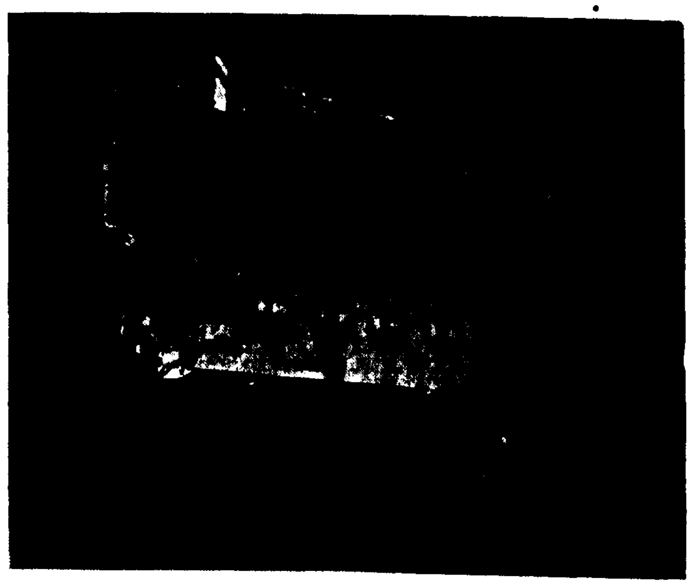
ROAD SWITCHER UNITS

After long experience with fully enclosed, streamlined-type cabs, ALCO produced in the late 1940's the first road-switcher, all-purpose locomotive. These units contain all the equipment of the so-called main-line unit, distributed within two narrow hoods to permit visibility in both directions.

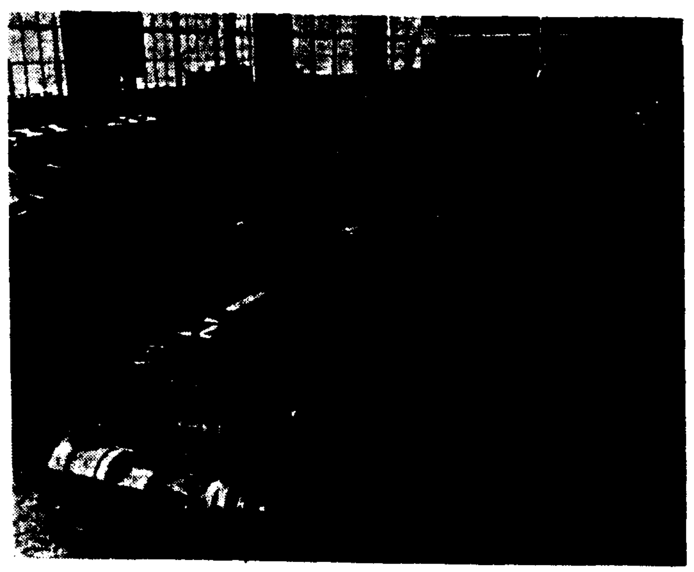
In pushing this important new design, destined to achieve universal acceptance because of its all-purpose utility, new frames had to be developed in which all the strength would come from the underframe proper, without assistance of the side trusses used in main-line units.

While this structure is heavier (for comparable strength) than a side-truss and underframe combination, ALCO succeeded in keeping the weight of the road switchers to the same level as that of earlier streamlined cab units.

The road-switcher type unit introduced by ALCO now accounts for a very substantial portion of the world's total locomotive production.



The 12-cylinder Model 251, 1800-hp. diesel engine built by ALCO Products, Inc. at Schenectady, New York. This engine later was installed in one of the DL-500 " World" locomotives shipped late in 1957 to the Indian Railways.

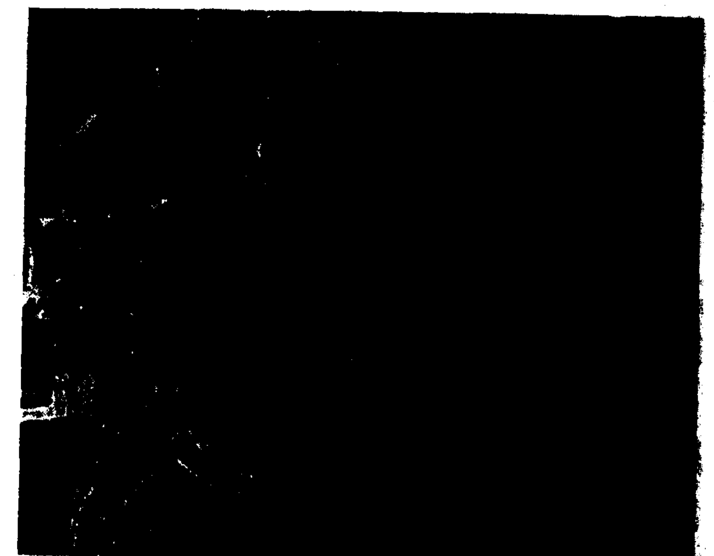


This modern machine tool at ALCO Products' Schenectady plant simultaneously bores crankshaft and camshaft channels in blocks for the Model 251 engine. ALCO engines not only power a wide range of diesel-electric locomotives, but also are in service in a variety of stationary and marine applications throughout the world.

An overall view of the diesel engine assembly line at the Schenectady plant of ALCO Products, Inc.

DIESELIZATION OVERSEAS

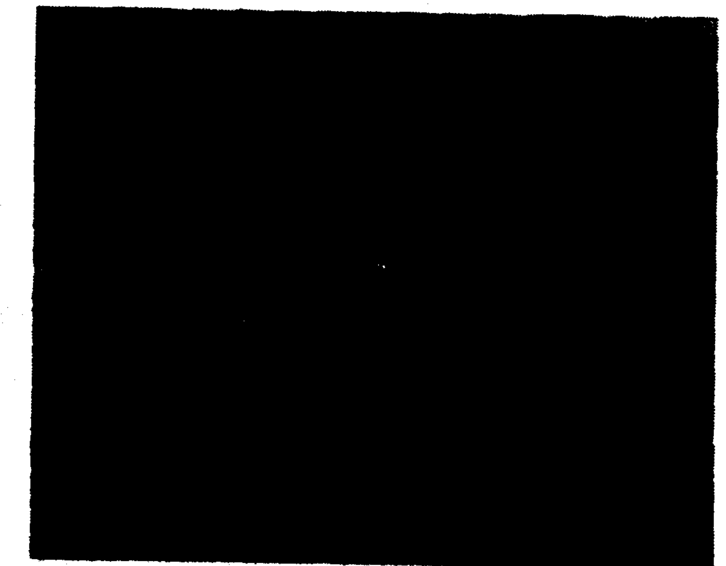
Dieselization was established on the railroads of the United States before circumstances made it a desirable advance for railroads of other countries. But once the trend began in other nations, it quickly gained momentum and now the smooth-running diesel-electric is rapidly replacing the steam locomotive around the globe.



Experienced shopmen put every ALCO diesel engine off the assembly line through extensive running tests prior to final inspection. Here tests are being run on an 1800-hp. 12-cylinder engine in the Model 251 series.

This ALCO DL-701, 1800-hp. road switcher was introduced at Schenectady in 1956 for domestic service, and now is in use throughout the United States. First units of an export counterpart, the DL-540, were built recently for delivery to Argentina.

Long before this world-wide trend became recognized, ALCO had exported a number of standard American-type locomotives mostly to Brazil and Mexico. It was clear, from the very beginning, that overseas application of these heavy units would be limited by the lighter axle loads permitted and by restrictions in the loading gauge.



Taken at the Port of New York in September, 1957, this photograph shows an ALCO DL-500 " World" locomotive during loading of the transport SS [illegible]. This locomotive was one of 20 in the shipment delivered at Calcutta in November for service on the Indian Railways. ALCO will build 80 more of the 1800-hp. units for the Indian Government.

At the same time, it was recognized that the goal to be sought was the preservation of all the features that had made ALCO locomotives successful in the United States.

These features included the excellent riding qualities of the company's cast-steel, fully equalized bogies, the general layout of the power plant and auxiliaries with an eye toward ease of maintenance, the simple cooling system and its drive through magnetic coupling, and the cab arrangement.

INTRODUCTION OF THE " WORLD " LOCOMOTIVE

Recognizing the need for an entirely new unit built exclusively for service overseas, ALCO designed and built a prototype of the DL-500 " World " locomotive that embodied all the features of the domestic units. This prototype was exhibited in 1953 at the 8th Panamerican Railways Congress in Atlantic City, New Jersey. The unit introduced a high-speed type, center loaded, cast steel swing-swivel bogie with three traction motors.

The locomotive had been carefully designed to meet all the restrictions of the Berne Conference international loading gauge. It could be built to the very low axle load of 16 long tons and made for all gauges from 1 meter to 5 feet 6 inches (1.678 meters).

In 1954 this locomotive was successfully demonstrated in Spain. It subsequently was purchased for revenue service and shortly was joined by more units. At that time, the "World" locomotive was equipped with the ALCO Model 244, 12-cylinder engine rated at 1600 hp. for traction, but it now is supplied with the more powerful 12-cylinder Model 251 vee-type engine, rated 1800 hp. for traction.

"World" locomotives with the Model 251 engine, are the model currently being delivered to the Indian Railways—identical in basic design with units now also in service in Argentina, Peru, Pakistan and Australia.

A hardened crankshaft for one of ALCO's Model 251 diesel engines is prepared for installation in an engine block. The Model 251 engine—standard on all ALCO locomotives for both domestic and export service—incorporates improvements developed after years of research and development.

EXPORT ROAD SWITCHERS

The DL-541, a road-switcher variation of the DL-500, followed, and a 900-hp. general purpose unit was offered to broaden the field covered by ALCO's line of standard light-weight locomotives for overseas use.

Another significant contribution of ALCO engineering to the development of the diesel-electric

This "Big Boy" steam locomotive, built by ALCO Products, Inc. for the Union Pacific Railroad prior to dieselization in the United States, was one of 20 similar units ranking as the world's biggest and most powerful. The locomotive weighs 596 tons with its tender, and consumed 10 to 12 tons of coal and 15,000 gallons of water each hour. It developed 7,000 horsepower and had a maximum speed of 80 miles an hour. The "Big Boy" was of mallet-type construction with an articulated, or hinged frame that enabled it to negotiate curves despite its 133-foot length.

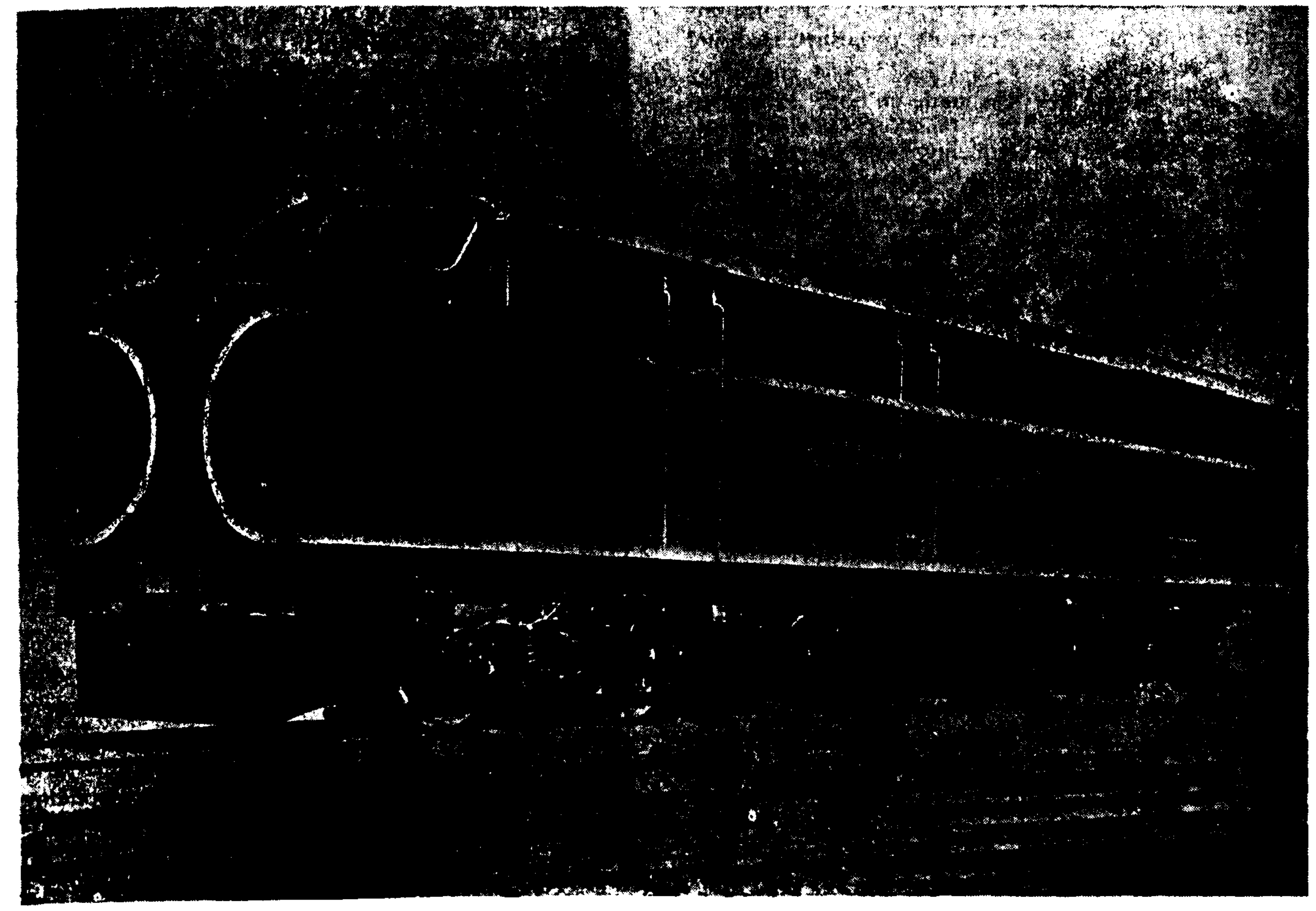
locomotive has been the perfection of the tri-mount type bogie. This is used for all-purpose locomotives where low weight transfer is essential to develop high tractive effort without wheel slippage.

The tri-mount bogie, wherein the locomotive weight is received by a conventional pivot at one end of the bogie frame and two friction pads at the other, results also in low-weight construction. An added advantage is a moderately short wheelbase. That, together with a low center of gravity, provides locomotives to which the bogie is applied with excellent riding abilities up to very high speeds.

This bogie is currently applied to the heavy duty 1800 hp. and 2400 hp. Co-Co locomotives built for American railways, and to the 900 hp. Co-Co standard light-weight export locomotive.

DIESEL ENGINE DEVELOPMENT—A MAJOR FACTOR

No discussion of diesel locomotive contributions would be complete without mention of diesel-engine advances over the years.



One of the ALCO "World" export-design locomotives built at Schenectady during 1957 for the Indian Railways.

ALCO Products has been engineering diesel engines since 1929, when the company purchased the McIntosh and Seymour Engine Company. This was a firm which had been building diesels since 1913 and had worked on reciprocating-engine production as early as 1886.

In the early years of the diesel locomotive, the size and weight of engines had been a disadvantage. As a result, ALCO and other major builders embarked on development programs with two objectives in mind: to retain the efficiency and durability of the diesel engine while at the same time reducing its weight.

Eventually progress was realized with the incorporation of higher strength materials, new construction methods, better combustion, and improved lubricants. When ALCO entered the diesel locomotive business as a volume producer, it immediately set out to overcome the weight disadvantage and other problems associated with diesel engines. The need was apparent: to pursue design of an engine that would be suitable in all respects for locomotive application.

McIntosh and Seymour engines had averaged almost 200 pounds per horsepower in weight. This ratio was reduced with development of a six-cylinder 9—1/2×10—1/2 inch, four stroke cycle engine that developed 300 hp. at 700 rpm. With an aluminum base, rods and pistons, this engine weighed only 47 pounds per horsepower, and had a piston speed of 1225 fpm. It was built from 1933 to 1944, and was the forerunner of ALCO's line of 9×10-1/2 inch engines.

After a period of successful development of a 12-1/2×13 inch engine, of which ALCO produced more than 4,000, the company in 1944 culminated three years of design work with the introduction of the Model 244, 9×10–1/2 inch engine. Incorporating the major advance of exhaust turbosupercharging applied originally to the 12–1/2×13 inch engine by ALCO, the Model 244 was made in both 12 and 16 cylinders.

This engine was a four-stroke cycle diesel that developed up to 2250 gross brake horsepower at a piston speed of 1750 fmp. and a BMEP of 170 psi. The engine weighed only 18.25 pounds per horsepower. It was produced until 1956.

Basic refinement of the Model 244 engine was begun in the late 1940's and resulted in development of the Model 251 series of engines. This power unit, produced today in six, 12 and 16-cylinder sizes, is perhaps the most modern diesel in the world.

The Model 251 is a 9×10–1/2 inch unit, and the 16-cylinder model develops 2550 gross brake horsepower at 1000 rpm. and a BMEP of 190 psi. The engine weighs only 17 pounds per horsepower—a small but significant weight advantage over preceding models.

The company's new vee-type engines are equipped with an ALCO developed-and-produced watercooled turbocharger; one of the most efficient available. They feature a high tensile-strength steel crankshaft, hardened to over 425 Brinnel.

Other advances incorporated into the Model 251 engine are hard bronze-lead bearings in which partial grooving and, in the case of the center main bearing, grooveless design has been employed to ensure the formation of a rich, full film of lubricating oil under all conditions.

The engines have stress-relieved welded-construction, wet-type cylinder blocks, and pistons with removable ring carriers and Ni-Resist inserts in the top ring groove. They also have Stellite-faced valves, Stellite valve-seat inserts, an intake-air aftercooler, Ni-Resist exhaust manifold and many other features.

ENGINE PROGRESS—A SUMMARY

In the years since 1929, diesel-engine development has seen the ratio of output to size increased by 16 to 1. New materials have been developed and incorporated and new, basic designs have been produced. BMEP's have more than doubled while structures have been improved immeasurably—all with corresponding improvements in production techniques and servicing.

ALCO has participated in all phases of this constant development program, and has led in many of the improvements now evident.

ELECTRIC MULTIPLE UNIT COACH

Unloading of the first consignment of Eastern Railway's electric multiple unit stock which arrived from West Germany by S. S. Indian Renown began at King George's Dock, Calcutta. Although the first electric trains to start from Howrah will be composed of electric locomotives and existing coaches, they will soon be replaced by electric multiple unit coaches. The unit consists of three coaches with a motor coach in the centre and two driving trailers, one at each end. The motor coach carries all the power equipment of the unit i.e. two pantographs on the top for drawing the control equipment, power equipment mounted on the underframe and a motor on the two 4-wheel bogies under the coach.

The width of the coaches is 12 ft. as compared with 10 ft. of that of the suburban steam trains. Thus these coaches will be able to carry a larger number of passengers. In fact, the carrying capacity of six new coaches will be equal to that of eight existing coaches. A maximum of four EMU coaches can be joined together. Initially, two such units will be joined to form a six-coach train during the peak period. During off-peak period a frequent service will be maintained by a 3-coach unit.

With a total carrying capacity of 580 passengers (seated and standing) an EMU stock can accelerate very rapidly—1.2 miles per hour per second. As it is also capable of quick braking it can attain very high speed between stations. Moreover, only one driver will be required to operate a train even when two or more units are joined together. When it arrives at a terminus all that the driver will have to do is to change ends and the train will be ready to depart on its return journey.

Tests to Determine the Most Suitable Type of Air Filter for Electric & Diesel Electric Railway Locomotive use in Industrial Areas

ELECTRIC and diesel-electric locomotives possess many characteristics making their use preferable to that of steam traction but their introduction has raised certain additional problems. Not the least of these is the necessity to supply a considerable volume of clean air for cooling and intake supply. Preliminary assessment of the requirements suggested that a number of aspects of the problem were not fully understood at the best approach seemed to be a series of controlled tests in service conditions with filters of varying characteristics.

It was necessary to narrow down the field, firstly on the basis of a theoretical assessment, and secondly, to those types shown by Laboratory tests to hold most promise. These aspects will be covered briefly in this report before proceeding to describe the field trials which were conducted on a series of electric locomotives running over the recently electrified Manchester-Sheffield-Wath extension.

THEORETICAL CONSIDERATIONS

The dust arresting performance of an oil wetted filter is dependent on two processes :

(a) effective impingement of dust on a large area of oily surface, and

(b) adequate retention properties to obviate subsequent re-entrainment of particles as the oil is " dried up " by collected solids.

If the oily surfaces are separated by relatively small passages, accumulation of dust causes appreciable reduction in flow area ; ultimately the spaces will be occupied by a porous bed of solids having the effect of maintaining filter efficiency even after the oil has been absorbed, at the cost of increased pressure loss.

Such filters are termed the " constant efficiency type ", and possess the advantage that solids " carry-through " does not occur, and need for servicing is positively indicated by increased back pressure.

However, it may not always be convenient to effect servicing immediately, and alternative filter arrangements are possible in which the spaces between oil wetted surfaces within the filter medium are purposely increased. Usually steps are taken to maintain adequate wetted area despite the increased voids by disposing the collecting surfaces in greater depth. It is possible to devise such filters with internal surface spacing sufficiently large to ensure adequate flow passage without this " bridging " tendency. During this process, the rise of pressure loss is small, at the expense of steadily reducing efficiency until ultimately the air passes through substantially uncleaned.

Although this may be advantageous where maintenance of full airflow is more important than transmission of solids if servicing is delayed or overlooked, dangers exist in that dislodgement of " cakes " of previously arrested dust may occur under conditions where vibration can accompany sudden surges of air flow, as for example when entering a tunnel at speed. Consequently, the use of filters with such " reducing efficiency " characteristics cannot be recommended.

The " herringbone " crimped wire mesh panels referred to later represent an improved version of this type, but even a short period of running following servicing suffices to show a marked reduction in efficiency, this continues progressively during subsequent running. This was later confirmed by the relatively dusty internal condition of the locomotive after test.

A prime aim of these tests was to ascertain the feasibility of combining both characteristics to a degree permitting full protection to be afforded in emergencies, over service intervals double that normally recommended. For a given pressure loss, more positive arrestation of particles is secured by employing the minimum possible spacing between wetted surfaces, and then securing maximum total open area by deploying the filter medium in deeply pleated formation. Oil wetted filters of this type include the Vokes 3-ply and 5-ply panels and so these both figured in subsequent tests.

Other types of filter which held promise employed various configurations of oil wetted surface, including knitted wire, variable density woven wire, herringbone crimped sheet metal, and neoprene bonded hair. All these were submitted to Laboratory testing as described below:

Laboratory Testing

Panels were made up of suitable dimensions for test, employing the following arrangements:

1. *Vokes 5-Ply*: The medium consists of three layers of wire mesh interspersed with two layers of cotton gauze. The latter serves the dual purpose of decreasing the average air passage dimensions, and acts as an absorbent to increase the effective mass of oil the panel can accommodate. The whole is deeply pleated to increase the total developed area to a maximum.

2. *Vokes 3-Ply*: Similar to 5-Ply but with only two layers of wire mesh and a single layer of cotton gauze between.

3. Wire mesh screens of variable bulk density, the more open mesh being upstream.

4. Neoprene bonded hair.

5. Woven wire screen; material similar to conventional oil bath scrubber pack.

6. Herringbone crimped wire; alternate layers with flutes in opposition.

7. Herringbone crimped sheet, with similar arrangement of layers.

Complete discussion of the Laboratory results is outside the scope of this report, but the following figures, indicating efficiency on test dust to B. S.

Specification 1701 will indicate the trend:

Filter Medium	Efficiency%		Pressure Loss ins. W. G.	
	initial	600 gms./ft.² load	initial	600 gms./ft.² load
Vokes 5-ply (oil wetted)	99	98.9	0.13	0.73
Vokes 3-ply (oil wetted)	99	98.8	0.06	0.48
Variable Density wire	93	74	0.13	0.62
Neoprene bonded hair	99	98.5	0.18	0.32
Woven wire	97	82	0.22	0.50
Herring bone crimped wire	99	55	0.04	0.05
Herringbone crimped sheet	75	50	0.08	0.09

Inspection of these figures indicates a marked variation in performance up to a considerable dust load, but it is possible to observe the fundamental differences between the virtually constant efficiency media such as the 5-ply and 3-ply, and the reducing efficiency types such as the herringbone crimped wires and sheets. Some types obviously possessed poor overall performance, and so were deleted from further work.

SERVICE TESTS

Although not covered in the Laboratory tests, some past experience on the 5-ply filter had been obtained in the dry state, and it seemed logical to include a number of these.

Practical limitations on service tests and desirability of obtaining fullest information on those chosen, made it necessary to exclude certain types with intermediate performance, such as the woven wire screen. However, from the service results it is possible by interpolation to estimate the performance to be expected from this pattern; efficiency would be considerably lower than with the 3-ply type but better than the herringbone crimped wire. Dust load capacity on the other hand would normally be rather inferior to either of the other varieties, but good pressure loss regulation would be achieved, in conjunction with substantially non-clogging characteristics.

Finally, therefore, the following were chosen for test:

(a) The Vokes 5-ply filter (dry).

(b) The Vokes 5-ply filter (oil wetted).

(c) The Vokes 3-ply filter (oil wetted).

(d) Oil wetted Neoprene bonded hair panels.

(e) Panels consisting of layers of wire mesh corrugated in herringbone formation with channels of adjacent layers running in opposition.

The prime aim of the investigation was to ascertain the most suitable type of filter for use in average conditions including those experienced in highly industrialised areas of the United Kingdom. Past experience in certain overseas markets had proved the 5-ply dry filter to be capable of satisfactory performance in conditions where dry inorganic dust predominated, but application of this type of filter for use in industrial areas had not met with such complete success and conventional reducing-efficiency oil wetted panels were equally open to criticism on account of low dust separating efficiency.

For the purpose of the tests, the recently electrified line between Manchester, Sheffield and Wath was chosen as this encountered a fair cross-section of conditions including areas where much soot and potentially corrosive contamination would be experienced. The tests were carried out on four locomotives of the Bo+Bo type used for both light goods and passenger transport. Each locomotive requires 18 panel filters passing a nominal 600 c. f. m. each, 17 being installed in the side walls and one to the H. T. compartment, which is an internal unit.

One type of filter only was fitted to a single locomotive but in some cases, opportunity was taken to employ alternative wetting oils and with the 5-ply filters, four dry units were employed with 13 of the wetted variety, to act as controls. Previous running had already been effected with the 5-ply filters in their dry state and criticism incurred through corrosion and difficulty in cleaning. It was in order to compare directly these effects with those experienced on the various oil wetted panels that the four dry filters were employed. Examination of used dry 5-ply panels had indicated that corrosion of the metallic parts had occurred and this assisted in the formation of a bond between the metal gauze and the tarry deposits, which was difficult to break down by normal solvent cleaning. There is little doubt also that this effect was aggravated by the inefficient performance of water separating louvres in front of the filters which had allowed rain to penetrate and assist in corrosion effects, particularly when other atmospheric agents were available.

Attempts were made to check the performance of the filters in terms of depression inside the locomotive at monthly intervals and in most cases, the filters were removed after operating for 60 days and returned to the Laboratory for individual pressure loss testing and assessment of collected solids. In certain cases, through service limitations, it was necessary to carry out this exercise at an earlier or later stage with the result that occasionally filters were left in situ for as long as 150 days.

Previous experience on the dry type 5-ply panels was largely reproduced in that rise of pressure loss with solids accumulation occurred more rapidly than with the oil wetted version of the same filter, and servicing by normal solvent processes was considerably more difficult. Also, performance of the bonded hair fibre panels showed a marked tendency in the same direction regarding pressure loss increase with dust load.

The oil wetted 5-ply panels exhibited quite good characteristics in respect of pressure loss rise and this has previously been proved due to the considerable quantity of oil which can be absorbed by the two layers of cotton scrim, allied to the large developed area of the deeply pleated 5-ply panel. These tests have proved that the oil wetted version is capable of retaining a larger quantity of solids than the dry version for a given rise in pressure loss.

Of all the types tested, the 3-ply oil wetted panel stood out as possessing the best combination of characteristics, with an efficiency assessed on the basis of locomotive cleanliness very little short of the 5-ply but with the capacity to operate for a considerably longer period without excessive rise of pressure loss. In one case, service contingencies made it impossible to clean the filters on the 3-ply fitted locomotive for 150 days and over his period the depression inside the cabin increased only from 0.09" w. g. to 0.28" w. g. Perhaps of even greater interest is that up to 120 days, only a very small increase to 0.12" had occurred.

Assessment of dust arresting efficiency was not directly possible but on the basis of internal cleanliness of the locomotive, these tests have shown that the 5-ply and 3-ply oil wetted filters maintained a cleaner condition than that possible with the other varieties of which the Neoprene bonded hair was considerably better than the herringbone wire.

DISCUSSION OF RESULTS

The Vokes 5-Ply (Dry) Filter

Past experience has shown this type to give good performance in certain overseas conditions, but this series of tests has confirmed that difficulty in servicing may be experienced with a combination of industrial pollution and rain ingress to promote corrosive bonding of contaminant to the filter.

Furthermore, whereas the oil wetted versions of this filter could retain over 200 grams of atmospheric contaminant for a pressure loss rise (on average) from 0.16″ w. g. to 0.20″ w. g. the dry 5-ply showed an increase from 0.13 to 0.46″ w. g. under the same conditions.

This indicates that the presence of oil on the filter assists rather than inhibits the formation of a highly porous bed of solids.

Experience showed that on an average, between 3,000 and 4,000 grams of solids (up to 9 lbs.) would be collected by the 17 main filters on a locomotive in 60 days average running.

If 6o days is accepted as a satisfactory filter servicing interval, the 5-ply *dry* filter would be excluded on grounds of excessive pressure loss increase, allied to difficulty in cleaning.

The Vokes 5-Ply Oil Wetted Filter

A few figures were quoted as comparisons under "5-ply dry filter", and it has been shown that this filter, despite its "constant efficiency" characteristics, can accommodate a remarkably large dust load for a modest increase in back pressure. Regular 60 day servicing by the means described later would ensure satisfactory performance under any circumstances likely to be experienced in other than dust storm conditions, and some latitude would exist to accommodate limited abuse due to delayed servicing.

The extent of this could not be determined, as the one extended test with the 5-ply filters to 130 days was rendered abortive through servicing having been effected on site without the filters first being returned to our Laboratory for testing in the loaded condition; however, a final depression in the loco of 0.7″ w. g. was recorded, and this is considered excessive. We would suggest the maximum emergency interval with 5-ply oil wetted filters should not exceed 90 days.

These filters maintained the locomotive interior in exceptionally clean condition throughout.

The Vokes 3-Ply Oil Wetted Filter

Owing to operating contingencies, it was not possible to effect servicing of the 3-ply filters until 150 days operation had been completed. Over this period, a solids weight of 8,580 grams was recorded on return of the panels to VOKES' Laboratory and as some would inevitably be lost in transit, the total collected must have been considerably greater.

This represents a loading of approximately 500 grams, or well over 1 lb. of solids per filter, and it is interesting to record that the locomotive depression only rose from 0.09 to 0.28″ w. g. over the whole period. At 120 days, a depression of 0.12″ w. g. was recorded, suggesting that approximately 1 lb. of atmospheric solids per panel can be accommodated on each oil wetted 3-ply filter panel for a very small increase in restriction. Allowing for contingencies, a normal servicing interval of 60 days would provide at least a 2 : 1 factor of safety against neglect or inability to service at the correct time.

The locomotive cabin condition was but little inferior to that noted following the 5-ply oil wetted filter tests.

The Neoprene Bonded Fibre Filter

Performance on laboratory tests had suggested that this type was a good intermediate between the constant efficiency 5-ply on the one hand and the reducing efficiency herringbone crimped types on the other. It was disappointing therefore, to record on the field trials, that these hopes were not borne out in practice.

Unfortunately, the first series of tests over a period of 60 days proved inconclusive due to a tendency

for the expanded metal facing to the hair pack to choke prematurely; as a consequence, an unduly rapid restriction rise was recorded, being 0.23 to 0.61″ w. g. for a period of 60 days and dust load of 3,337 grams (7 lb.).

The test was repeated with the offending facing replaced by a suitably open mesh, and results improved considerably over the ensuing 60 days. For some reason not fully understood, the weight of dust collected during the second period fell to just under 2,000 grams (4.5 lb.), for which load the restriction rose from 0.21″ w. g. to 0.27″ w. g.

Test results for later running periods of longer duration are not yet complete, but the indicated pattern to date is similar.

The conclusion to be drawn so far is that this type of filter possesses a reasonably flat pressure loss/dust load characteristic, but this is at a generally higher level—over double—that recorded for the 3-ply type filter.

Examination of the locomotive interior during and after test revealed that more solids had penetrated this filter than was the case with the 3 and 5-ply varieties, and the overall balance was considerably in favour of the latter types.

It was subsequently learned that use of this type of filter would be excluded from locomotive wall service on account of excessive fire risk from hot cinders, etc.

The Herringbone Wire Panels

Although a considerable running period has been effected with these panels in situ (115 days), unfortunately servicing had been effected on site, and it was not possible to carry out the usual inspection and pressure loss tests at our Laboratory.

However, a surprisingly rapid locomotive depression rise was recorded, from 0.10″ w. g. initial, to 0.7″ w. g. at 115 days. This was considerably in excess of that noted for the 3-ply filters after 150 days, despite the positive retention characteristics of the latter. In view of the markedly dirtier condition of the locomotive during and after test, this type of filter is definitely not favoured, especially as the hoped for non-clogging characteristics were not realised in practice to an extent justifying the observed rapid efficiency reduction with increasing dust load.

FILTER SERVICING

For the purpose of these tests, the filter panels were returned after use to VOKES Laboratory so that inspection and pressure loss tests at standard airflow could be effected before cleaning; washing off and re-oiling were then carried out in a special machine devised to facilitate these operations. One such machine has now been installed at Reddish Depot, Manchester, by British Railways, and is in regular use.

The machine includes suitable washing and wetting tanks disposed around a centrifuge to accelerate drainage of excess fluids from the panels. The most effective cleansing agent has proved to be "Liquid Solvex", a product of the Fletcher Miller Company, and one tank contains this hydrocarbon base, water soluble solvent, and emulsifying agent.

A second tank contains hot water (60—70°C.) for the purpose of wetting out the solvent and removing the collected solids, and the third tank holds the wetting oil.

WETTING OILS

Opportunity was taken of the field trials to compare two wetting fluids, a straight mineral/vegetable blend oil in wide use for the purpose, and a water soluble emulsified oil of generally similar characteristics.

Performance of these two fluids as filter wetting agents proved to be very similar, and no conclusions can be drawn to favour one or the other. However, the water soluble oil proved of great advantage for servicing as soaking times in the solvent and water tanks could be usefully reduced for equal effectiveness. We tend therefore to favour use of the soluble oil for wetting filter panels for this service.

A word should be added regarding the special air filter wetting oils recently made available in Great

Britain. Test results have been quoted by the sponsors indicating a usefully improved performance when applied to "reducing-efficiency" filters in certain overseas service.

The special oils were not available in time to permit inclusion in the field trials, but laboratory tests have been carried out by us in co-operation with the suppliers. Briefly, the object of these fluids is to secure at once the good wetting and wicking characteristics of a light mineral oil, together with anti-draining properties offered by the presence of a semi-soluble additive. The effect is to increase substantially the mass of oil a given filter can retain after servicing, and so provide good surface wetting of the accumulated dust pack beyond the point at which a conventional oil would be fully absorbed.

The advantages are greatest with the "reducing efficiency" type of open pack filter which is enabled to operate for a longer period before serious deterioration of collecting performance sets in. Applied to filters such as the 5-ply and 3-ply however, which are themselves designed to possess good wicking and anti-draining properties, the advantages are not so marked, and unless due precautions in draining at an adequately high temperature are observed, a possibility of excessive oil retention exists, which could cause abnormally high back pressure. Experimental work is continuing in co-operation with the suppliers. Advantages are greatest when applied to filters possessing poor retention characteristics.

EXCLUSION OF RAIN WATER

Comment has already been passed on the effects experienced due to water ingress on the dry 5-ply filters. Presence of water on any dry or viscous panels is obviously disadvantageous and if the recommended water soluble wetting oils are employed, long term performance would be affected due to removal of wetting fluid.

The VOKES "Monsoon" type louvre has been expressly designed to exclude rain water, which it does most efficiently, and irrespective of the type of filter employed, fitment of these or equivalent louvres is highly desirable to secure optimum filter performance.

CONCLUSIONS

The field trials show one type of panel filter, namely the VOKES 3-ply (oil wetted) to be markedly superior to all the alternatives, and using the ratings applied during these tests—i. e., a face velocity of approximately 300 feet/minute—excellent performance, with neither efficiency fall off nor premature choking, can be achieved over a period of 120 days average operation under industrial conditions in the U. K.

Allowing for emergencies and service contingencies, a nominal service interval of 60 days, would provide a factor of safety of over 2 : 1. Such performance could not be achieved with any of the other filters, including the herringbone crimped wire mesh and Neoprene bonded hair panels.

U. S. FIRM RECEIVES BIG ORDER FROM INDIA

The Hewitt Robins Company has received a 5.5 million dollar order for construction of a material handling system from an iron ore mine in India.

The order, largest in its history, calls for design, fabrication and erection of a two mile conveyor system with related facilities to take ore as it comes from the mine, process it to specifications, and load it into railroad cars for shipment to a steel plant.

The mine, Hewitt said, is on top of a 2,600-foot mountain 225 miles south-west of Calcutta, in a dense Bamboo Jungle.

LOCOMOTIVE BRAKES

From A Technical Correspondent

THE trend of modern locomotive design tends to a concentration of the control and driving apparatus in order to obtain short locomotive units. Besides of that, there is now, contrary to former ideas, a tendency to save weight of the engine plant itself and the additional devices.

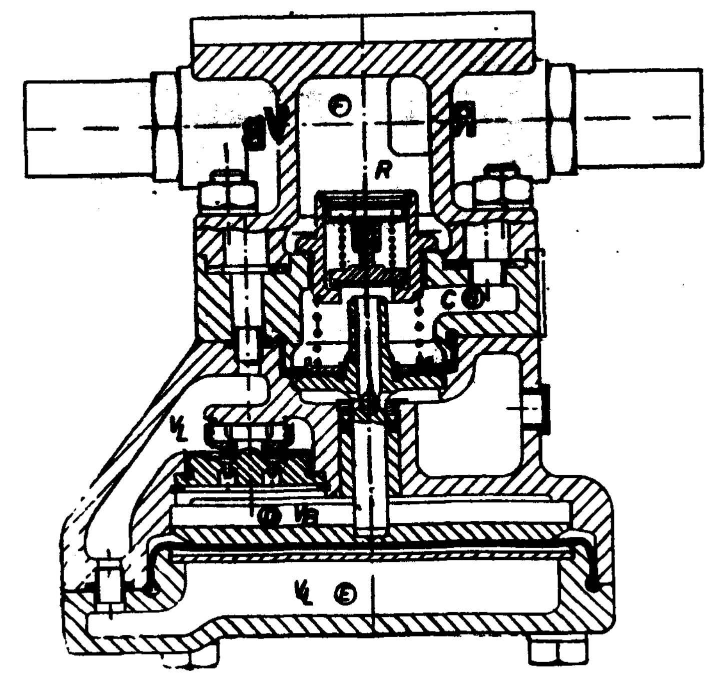


Fig. 1. Vacuum Control Valve

These considerations have also been applied to the brakes. The vacuum brake which is in common use in this country as in numerous other countries all over the world is characterized by the very low differential which is at disposal for creating the braking force. This leads to large dimensions of the brake cylinder and high weight. With the compressed air brake the pressure differential is theoretically unlimited, practically it amounts to about 10 times of that of the vacuum brake. This leads to small and light brake cylinders. The KNORR-Bremse has therefore been providing compressed air brakes for locomotives combined with vacuum braking for the trains now for many years.

Compressed air is on the other hand of great use and really necessary for sanding, window-sweeping, pneumatic control of the engine plant and other purposes. Therefore a compressor plant is necessary anyway, even on the locomotive which is fully vacuum braked.

Lately, the design of the combined devices for locomotive brakes has been thoroughly revised by the Knorr-Bremse. This led to a modernisation and to very decided advantages compared to the old apparatus.

These advantages aim at decreasing weight and volume, better performance and easier maintenance.

Figure 1 shows the vacuum control valve which synchronises the operation of the locomotive and train brake. In this valve a new type of rubber diaphragm is installed which gives a very flexible operation though it requires only little space.

The same applies to the combined vacuum pressure brake valve shown in figure 2. The slide valves which had been in common use for the brake valves of the past are replaced by poppet valves controlled by cams. The dimensions of this engineer's brake valve are remarkably small. A very high flexibility of operation, little wear of the moving parts are essential improvements.

A modern brake cylinder of pressed steel is shown in figure 3. It incorporates a return spring for the brake gear and very effective dust protection.

The Knorr-Bremse is doing a considerable amount of development work in its very well equipped test department in Munich. High capacity brakes for

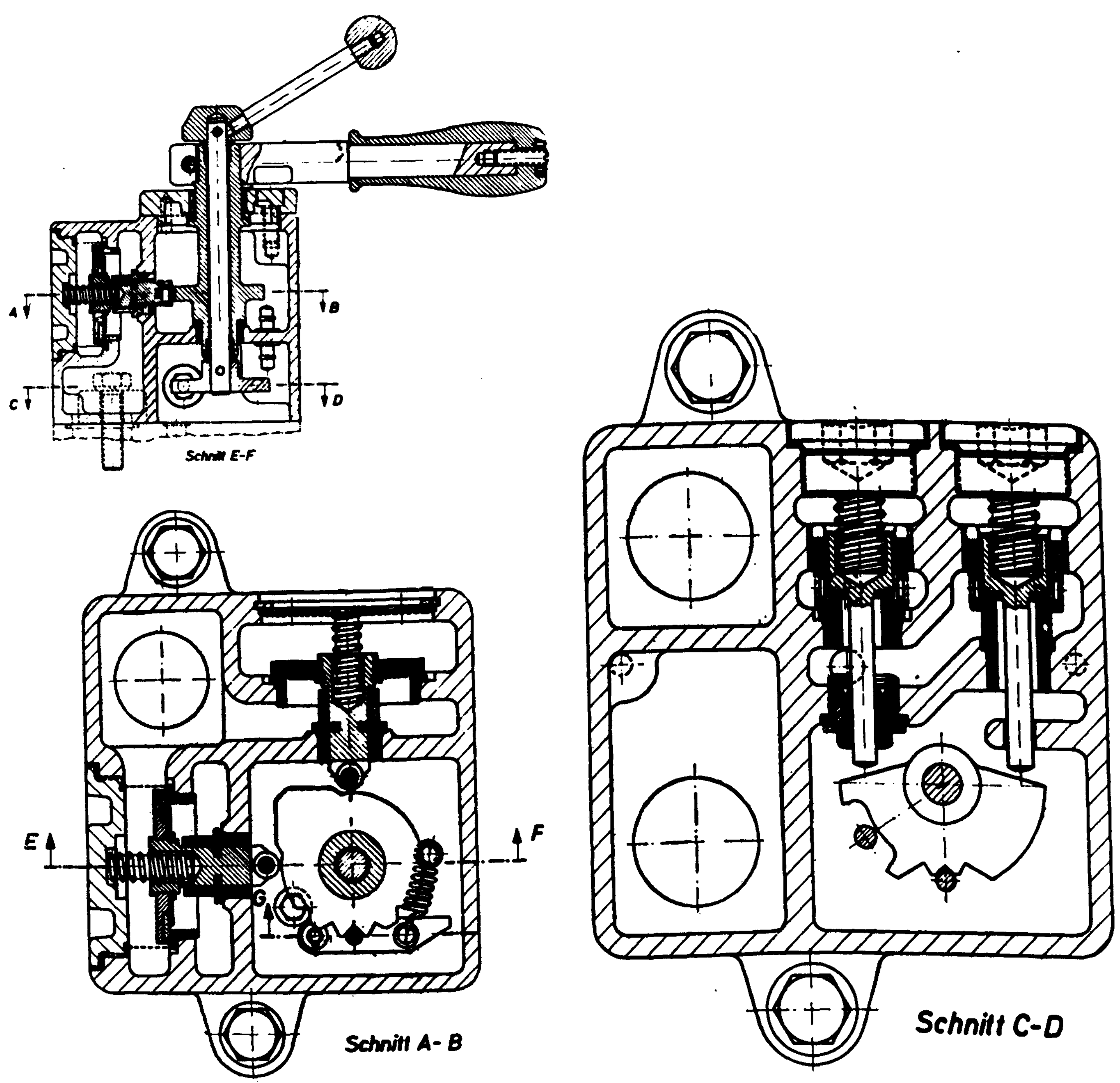
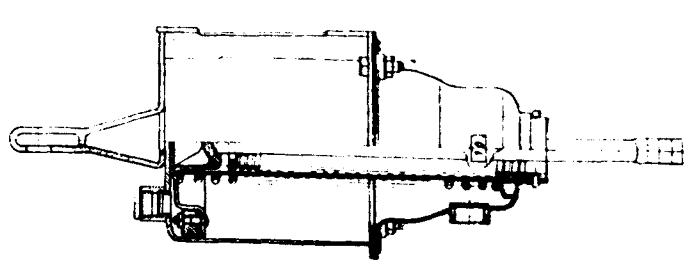


Fig. 2. Combined Vacuum Pressure Brake Valve.



← *Fig. 3. Pressed Steel Brake Cylinder with incorporated rigging return spring.*

high speed, anti-sliding devices and automatic brake valves for long and heavy trains are some of the results which are also of great interest for locomotives.

Cost Reductions for the DSB attained with the MY-Locomotives

By E. Risbjerg Thomsen

IN earlier articles in "Vingehjulet", among others that published on September 25th, 1955, certain information was given as to the cost reduction which the Danish State Railways (DSB) have attained by using the large Diesel locomotives of the MY-type. This information was based on the experience gained during the service of the first four MY-locomotives, Nos. 1101-1104, which were taken into operation in 1954.

In addition to the experience gathered with the first four locomotives, we have at our disposal also the results covering the operation of the following series of 20 MY-locomotives MY 1105—1124. These were delivered during the period February 1956—November 1956. Naturally it is only now, after all 24 locomotives have been put in service, that the cost saving anticipated with regard to the expenses for fuel begins to show its proper effect.

Manufacturing NOHAB-GM diesel-electric locomotives in NOHAB'S shop.

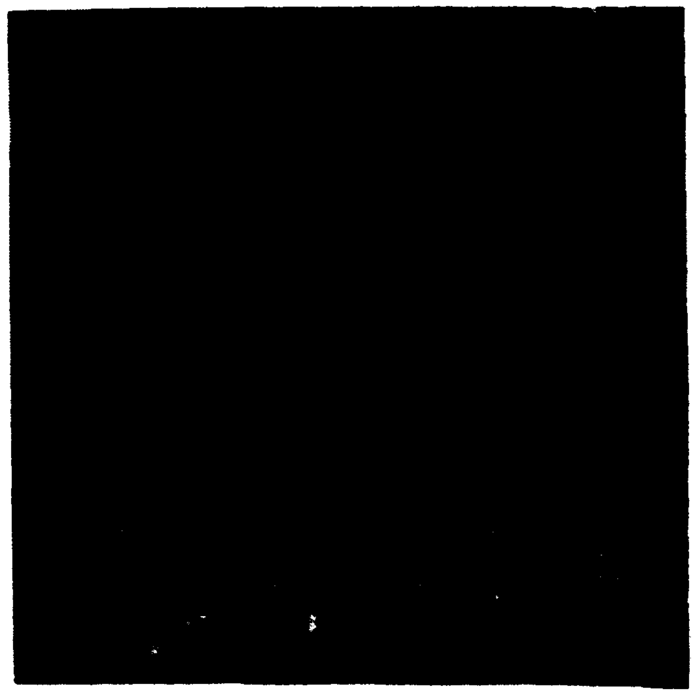
In the official monthly reports from the DSB it may be seen by perusing the statistics for the months in 1957 for which results have been published that the total fuel costs for the locomotives and the motor-coaches have fallen with respect to the normal run of costs for 1956. For example, it may be seen that in February 1956 the fuel costs were 4.6 mil. Danish crowns but that this cost fell to 4.1 mil. Danish crowns in February 1957.

This has occurred in spite of the fact that the fuel costs have increased for both coal and fuel oil and that more transport work was carried out in 1957 than in 1956. This latter fact is apparent from the index in the statistics which denotes the amount of gross ton/kilometers performed which, for example, was 621 mil. in February 1957, as compared with 587 in February 1956. Furthermore, it is interesting to see that simultaneously with the increase of the transport work performed, expressed in gross ton/kilometers, there has in relation hereto been a decrease in the number of train kilometers travelled, which for instance in February 1956 was 2.94 mil., as compared with 2.91 mil. in February 1957.

The adoption of the 20 MY-locomotives which were put into service after February 1956, replacing steam locomotives has, in other words, resulted in longer and fewer trains than previously. This is, from an economical point of view, a desirable development which, in spite of the increased fuel prices, has contributed to a considerable reduction in the total fuel cost of the State railways.

At the same time the new locomotives have, as is well known, made it possible to improve the train-schedules, as a result of the greater speeds attained by both the more important express trains and the freight trains. To this must be added the savings that were made even on other fronts besides that of the fuel costs, as will be shown below.

Besides the summary information given in the official monthly statistics, the DSB have internal information which is much more detailed and which contains interesting facts concerning the performances of the new locomotives with regard to their operation and the favourable results which have been obtained with them. It may be mentioned that statistics kept covering the last delivered 20 locomotives (MY 1105-1124) show that these, from the moment they were put into operation in 1956 and up to June 1957 (an average of 11½ months per locomotive, or barely one year's operational service) have together used



Lowering the body of a NOHAB-GM diesel-electric locomotive.

approximately 13,000 tons of fuel oil and have performed a total transport work of 2,000 mil. gross ton kilometers.

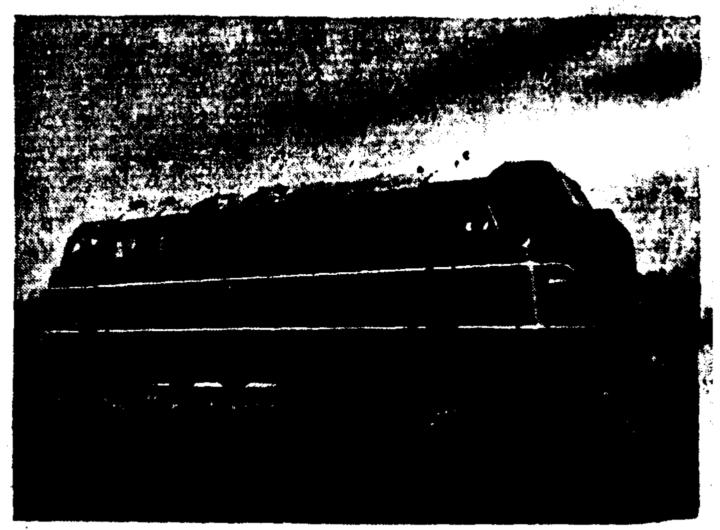
This last figure shows what the 20 latest delivered locomotives have achieved, since 2,000 mil. gross ton kilometers corresponds to hauling a train with a weight of 400 tons over a distance of 5 mil. kilometers. Expressed in another way, each of the new locomotives has, on an average during barely a year's service, delivered an amount of power corresponding to that required for an express train consisting of 11 coaches to go six times round the world.

With the available statistics as a basis for the calculation of fuel consumption and price conditions for coal and fuel oil, respectively, the fact may be derived that the 20 locomotives, up to June 1st, 1957, have attained a total reduction in coal consumption of approximately 90,000 tons, which corresponds to ten large coal ship loads. Converted to railway trucks, it would correspond to a train set which would stretch from Copenhagen through Roskilde to Viby Sjaelland. The cost reduction, seen as the difference between the coal costs saved and the actual expenses for fuel oil, totally over the period in question about 9.5 mil. Danish crowns. The savings which have been attained only with regard to fuel costs will therefore imply a yearly reduction of about half a mil. Danish crowns per locomotive, for the locomotives MY 1105—1124.

In a similar way it appears from the accounts kept for the first four MY-locomotives (1101 - 1104), operating on the same routes as MY 1105 - 1124, that from the time they were put into service in the first half of 1954 and until June 1st, 1957, they have consumed a total of 7,500 tons of fuel oil and during this time performed 1,250 mil. gross ton kilometers. The savings on the fuel budget alone can thus be calculated to approximately 6 mil. Danish crowns. These savings in fuel costs are particularly favourable as they reduce currency expenditure.

It may be noted that the increase in fuel oil prices which occurred as a result of the Suez crisis has not resulted in a reduction in the saving, since this increase was entirely counterbalanced by the simultaneous rise of the coal prices. Even a considerable increase in the price of oil does not assert itself in the budget in the same manner as increases in coal prices, as an increase of 100 crowns per ton oil does not have a greater effect on the fuel costs than an increase of coal prices of approximately 15 crowns per ton.

As has been mentioned in the article referred to in "Vingehjulet" of September 25th, 1955, a special book-keeping system for all expenses paid for operational and maintenance costs of the four first MY-locomotives, in comparison with the corresponding expenses for the four steam locomotives, was introduced from June 1st, 1954, in the Second District and at the Central Workshops at Aarhus. This book-keeping system has successively been extended to include the other MY-locomotives as they were taken into operation.



One of the NOHAB-GM diesel-electric locomotives, delivered to the Danish State Railways.

The following table shows the results attained for the four MY-locomotives as compared with four E-locomotives during the period June 15th, 1954, to June 30th, 1956.

Expenses incurred by four MY-locomotives (Nos. 1101-1104) as compared with four E-locomotives (Nos. 964, 969, 991 and 992) during the period June 15th, 1954, to June 30th, 1956.

LOCOMOTIVE PERFORMANCES

	My-loco	E-loco
Total distance train kilometers	1,879,593	841,151
Gross ton km in 1,000, total	841,023	254,208
Train km per locomotive per year	230,154	102,998
Gross ton km in 1,000, per locomotive per year	102.982	31,128
Average train weight in tons	447	302

EXPENSES IN DANISH CROWNS PER 1,000 TON KM

Fuel oil and coal (including train heating)	1.70	6.96
Lubricating oil	0.06	0.07
Water	0.01	0.20
Locomotive personnel (data from 1954, 1955)	0.70	2.01
Attendance	0.09	0.30
Maintenance	0.29	1.04

EXPENSES IN DANISH CROWNS PER TRAIN KM

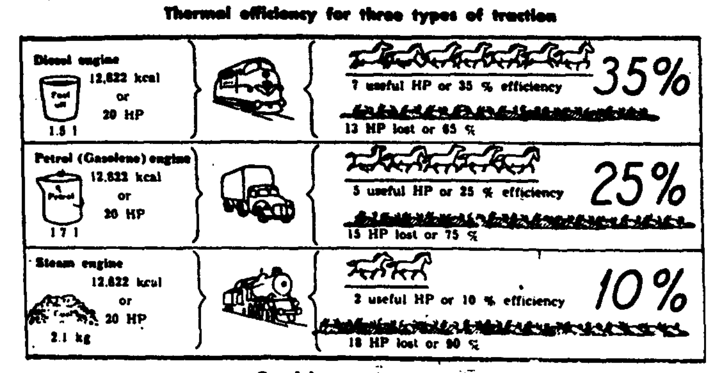
Fuel oil and coal (including train heating)	0.76	2.12
Lubricating oil	0.03	0.02
Water	0.00	0.06
Locomotive personnel (data from 1954, 1955)	0.32	0.60
Attendance	0.04	0.07
Maintenance	0.13	0.31

It may be seen from this table, with reference to the previously published table for the first part of the period, that as the new Diesel locomotives were put into service they successively have reduced the use of the steam locomotives so that these latter will travel shorter distances expressed in km/day. Due to this fact, the basis for the comparison has become somewhat distorted and the special book-keeping for the steam locomotives has therefore been discontinued. In the case of the previously mentioned calculations the reduction in fuel costs which the Diesel locomotives attain is reckoned with reference to the steam locomotive performances before these were restricted in service due to the fact that the Diesel locomotives have partly suppressed their use.

The experience hitherto obtained with regard to the various expenses for steam locomotives, and which comprises not only the fuel costs but also maintenance and operational costs, is sufficient for making the necessary comparisons. On the other hand, a continued control of the expenses for the Diesel locomotives is of great interest, since the material is new and the experience gained under European conditions so far rather limited, whereas there is ample experience from USA with over 20,000 locomotives.

When comparing the tables it appears that the maintenance costs for the MY-locomotives, although still very low, are somewhat higher during the second year of operation than during the first. This was to be expected since, besides the 75,000 km and the 150,000 km overhauls during the first year, now also the 300,000 km overhaul has come into the picture.

Thermal efficiency for three types of traction



Dead horses do no work

This drawing is taken from an American leaflet which attempts to show why the Diesel locomotive gives a higher power output and therefore a better operational economy than the Steam locomotive. The figures are rounded off so as to fit the drawing; but it is obvious that with a smaller quantity of oil than coal it is possible to develop greater power and efficiency, and this is the main reason for the explanation as to why, during the present time of increased costs, the MY-locomotives reduce costs to such an extent for the DSB.

The book-keeping schedule for the period June 15th, 1954,—June 30th, 1957, will have to include also the 600,000 overhaul which will naturally once again result in a rise in maintenance costs. After this, however, a long time will elapse before any essential alterations occur, since the 600,000 km overhaul is the only major inspection of the Diesel engine and other parts which is to be carried out within 1,8 kilometer, corresponding to 8 – 9 years service.

The above mentioned 600,000 km overhaul was carried out in December 1956 and during the first months of 1957 and up to the present it can be stated that the extent of the work undertaken and the outlay dependent hereon have not exceeded the expected values. The DSB have hitherto assumed that the outlay for repair and maintenance of MY-locomotives will be about 3/4 of that for the DSB's larger steam locomotives and the experience gained up to now has strengthened this belief.

The new locomotives thus result in a saving on the maintenance side of the account as well and, as is apparent from the above table, savings are also made on several other factors of which the reduction of the outlay for locomotive personnel is the most obvious.

Summing up the savings (as of June 1st, 1957) attained by the locomotives MY 1101 — 1104 during 3 years of service, the fuel savings, approximately 6 mil. Danish crowns, and the other savings accounted for, have exceeded the purchase cost of the locomotives. The same result can be expected for the locomotives MY 1105 — 1124 which saved during the first year, half a million Danish crowns per locomotive on fuel costs alone, which is even more than was expected when the locomotives were purchased.

During 1957 and in the beginning of 1957 another 22 MY-locomotives will be put into operation, namely: MY 1201 - 1202 from A/S Frichs and MY 1125 - 1144, which are of the same type as the locomotives 1106 - 1124. Naturally, it will be more difficult to attain the same degree of utilization of these locomotives as was the case for the first 24. However, the intention is to take this into consideration when making up the new train schedules, running distances and all the other preliminary work. This will be done in order to ensure that the new locomotives will not only increase the train speeds but will also haul as many tons as possible so that they will give the greatest possible economic returns for the DSB.

NEW RESERVES IN RAJASTHAN

Manganese ore reserves of approximately 250,000 tons in Udaipur and Banswara areas in Rajasthan State have been estimated by the Geological Survey of India. The reserves, which lie at a depth of between 30 and 50 ft., contain 40 to 50 per cent of manganese.

(Continued from page 28)

The substation control cabling is carried in sheet-steel trunking, and carefully planned marshalling cabinets, at one end of each line of D. C. truck switch-gear, facilitate the installation, checking and testing of the control and indicating circuits in the substation. The final control marshalling cabinet is situated on the upper floor adjacent to the rectifier relay board. Without these marshalling arrangements, the change-over of the traction current feeds from the old sub-station to the new would be virtually impossible during the few night hours when the station can be shut down.

THE CHANGEOVER

As the substation serves three separate Underground lines, the changeover from the old to new cannot be carried out overnight. Instead, the track feeders are being dealt with one at a time, and only at weekends, when longer track possessions are possible. To date, the four sections of the District Line have been changed over and are now fed from the new substation.

All the new equipment is temporarily remote-controlled from the old substation by a centralised control panel, which was designed and produced by London Transport staff. In the near future permanent control panels will be installed in a Control Room, on the upper floor of the new building. These panels will also provide remote-control for the rotary converter substation at Lambeth, which has hitherto been controlled from the old Charing Cross substation. This work is being carried out by London Transport staff. Space is available for similar equipment for the remote-control of four or five other substations.

It is expected that the last of the traction feeds will be connected to the new substation early in the New Year, but completion of the connection of the auxiliary supplies will not be possible before next spring.

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