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INDEX TO ADVERTISERS

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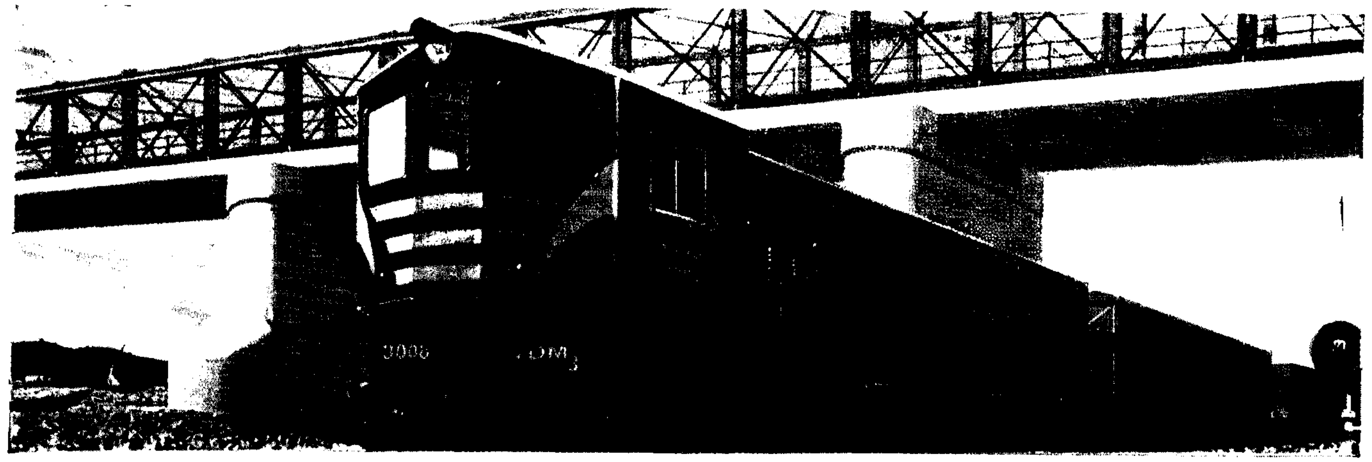
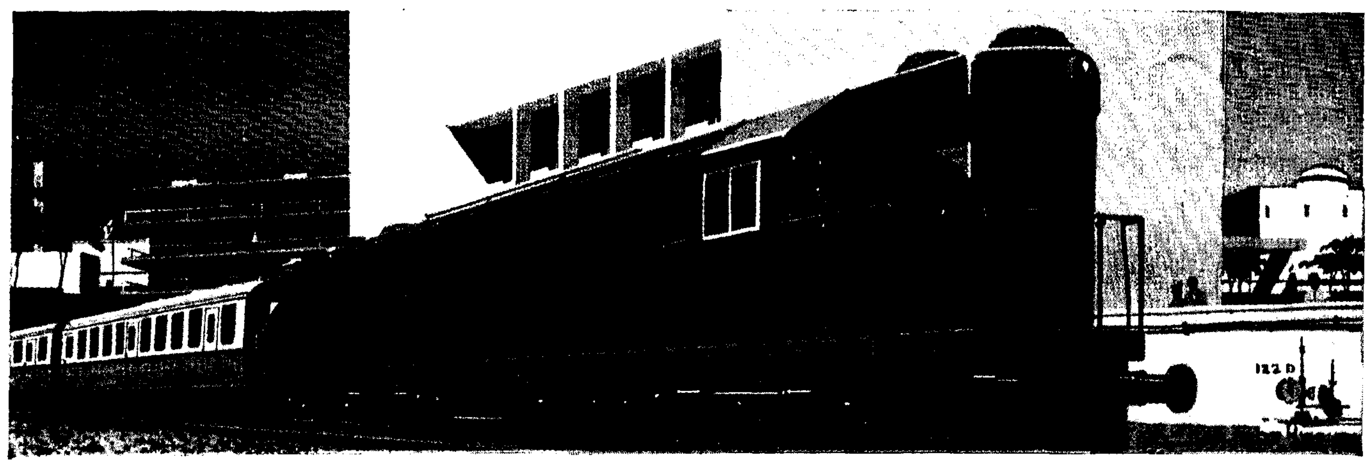


Indian Railways purchase 70

GENERAL MOTORS LOCOMOTIVES



Deliveries will begin this year on the first General Motors Diesel-Electric locomotives to go to India 70 units built to meet Indian Railway specifications.

Forty Model GT16, 2,600/2,400 h.p., broad-gauge locomotives have been ordered for the Northern Railway. Largest, most powerful General Motors locomotives ever offered overseas, these units will be based at Moghal Sarai and will be used in time freight operations hauling heavy goods trains.

Thirty Model GA12 meter-gauge locomotives will be delivered to the North-east Frontier Railway and will be maintained at Siliguri. These 1,240/1,150 h.p. locomotives, rated to insure 1,150 h.p. under site conditions for tractive purpose, will also be used to handle increasing goods traffic. Equipped with 1-B-B-1 wheel arrangement, they have a 12-ton axle load and will provide excellent riding characteristics as well as reduced rail stresses with less rail and flange wear.

Addition of India to our honour roll of customers brings the number of countries where General Motors locomotives operate to a total of 38. Throughout the world GM locomotives have established unparalleled records for high tonnage operation at lowest cost. Whether the need is for one locomotive or a fleet, railways can count upon the complete co-operation of the world's most experienced builder of Diesel motive power. Your inquiry will receive prompt attention.

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LOCOMOTIVE PLANTS: Electro-Motive Division of General Motors, La Grange, Illinois, U. S. A. General Motors Diesel Limited, London, Ontario, Canada

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GM DIESEL POWER

GENERAL MOTORS LOCOMOTIVES

World's Highest Standard — 270 to 2600 H. P.

(A QUARTERLY JOURNAL DEVOTED TO RAILWAY MATTERS OF TECHNICAL INTEREST)

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Chittaranjan Locomotive Works Supplement

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Chittaranjan & The Engineer

"Si monumentum videris, Circumspice" which when translated from the Latin means "if you wish to see my work have a look around". This was said by a great Roman, and could be applied with truth to the achievements of our Government and its people.

Among other major achievements Chittaranjan Locomotive Works stand out as a beacon light which symbolises the New India—an India of which we can all be proud, an India which can hold up its head in the nations of the World and say "if you want to see progress well here it is".

The man whose name is perpetuated in these works was an outstanding personality in many ways. A great lawyer and philanthropist, he was also an eminent poet. But it is not because of these qualifications and qualities that he is remembered to-day, but because of his intense patriotism and great leadership of men and movements for the emancipation of the country. In the course of his many addresses to the people he once said these inspiring words "If I die on this work of winning freedom, I believe I will be born in this country again and again, living for it, hoping for it, working for it with all the energy of my life, with all the love of my nature till I see the fulfilment of my hope and the realisation of my dreams". Deshbandu died but his name will live as long as Chittaranjan Locomotive Works last.

Chittaranjan, formerly called Mihijam 148 miles from Calcutta is not just as another scheme, it is a solid achievement. Within few years of our independence, what was once a semi jungle inhabited in part by a few aboriginals living in mud huts so symbolic of old India now throbs with twentieth century life.

A band of pioneers, whose names deserve to be enscrolled in letters of gold when the history of Free India is written, have converted 4000 acres of undulating land into a modern township and in the centre of this land stands the Locomotive Factory.

The vital reasons which prompted the Government of India to undertake this gigantic enterprise in the Public Sector are perhaps not so well known.

Prior to World War II, India had no difficulty in importing Locomotives and spare parts to meet the demands of our Railways but as the war developed serious difficulties were experienced in these imports with the result that railway transport was seriously jeopardised. On the existing locomotives, some of which had passed their economic life fell the brunt of maintaining India's Railway Transport. These engines were thrashed to the utmost limits, with cracked frames patched in more places than one, with boilers repaired by welding over and over again until their safety became a serious problem, with axles worn down to their bare safe limits, the position of locomotive usage became a major obstacle.

As a result, cuts had to be enforced in passenger travel facilities, and the speeds of trains had to be reduced to ensure safe working and gradually the stage was reached where rail transport was likely to grind itself down to a stoppage.

Troop movements and war material movement had to be maintained whatever the cost and under any circumstances and it was not until America came to the rescue with locomotives and wagons, that India could breath a sigh of relief and carry on railway operations to meet the war effort in India.

Knowing how the railway system of India came to a near disaster, when we got our Independence, the first thought that engaged the minds of our planners was to make India independent for locomotives from foreign sources, and although India was short of both finance and a sufficient number of highly qualified technical staff a decision was taken to build our own locomotives come what may.

With the help of British Locomotive Builders Association, the Chittaranjan Works were planned, for all the individual workshops pertaining to locomotive building and the list of machinery of each shop was drawn up and orders placed.

As soon as the plans of the workshops were in the hands of our Civil Engineers they started on them in right earnest and without delay they placed orders for the structural fabrications and putting up the walls and floors. When the structures arrived they were placed on the walls and the roofs completed. There was a frightful hurry to complete the workshops in the scheduled times laid down and our engineers excelled themselves by working even faster and completing the buildings ahead of that time.

In the meantime the machinery arrived and was put in position in each shops, foundations prepared and machinery erected with clock work precision, and the workshops were starting to take shape for the building of our own locomotives.

As these were built to our standard Railway Board design and specifications they were well known to our Mechanical Engineers and a few of the top men only of the British Locomotive Building Industry were imported as advisers and consultants and under their guidance the locomotives started taking shape.

On the 1st of November, 1950, the first locomotive to be assembled in Chittaranjan rolled out of the Assembly Lines. Though this first locomotive was manufactured abroad more work went into its assembly than normal and as the workshop manufacture progressed the import of whole locomotives and spare parts for assembly gradually declined.

The target of 120 locomotives and 50 boilers per annum was reached and exceeded in a few more years.

In the early years the cost of locomotives turned out were higher than those imported, but very soon our Production Engineers got busy analysing the reasons for the high costs, and by introducing work study and time study methods, and paving down unnecessary expense were able to reach a figure lower than that of the imported locomotive.

There were many advantages for selecting Chittaranjan as the site for India's up to date Locomotive Factory and among these may be mentioned proximity to the biggest coal fields of Bengal. Labour was both plentiful and cheap, and the area was so vast that there was plenty of room for expansion. The biggest factor in its favour was that Chittaranjan lies within easy reach of the Damodar Valley Electric Grid and there would never be a shortage of electric power required for each and every shop.

Chittaranjan also lended itself to the development of a fairly large township in order to house the thousands of technical and other staff and their families with all amenities in the proximity such as Bazars, Shops, Hospitals, Schools for children, recreation and playground and places of religious worship.

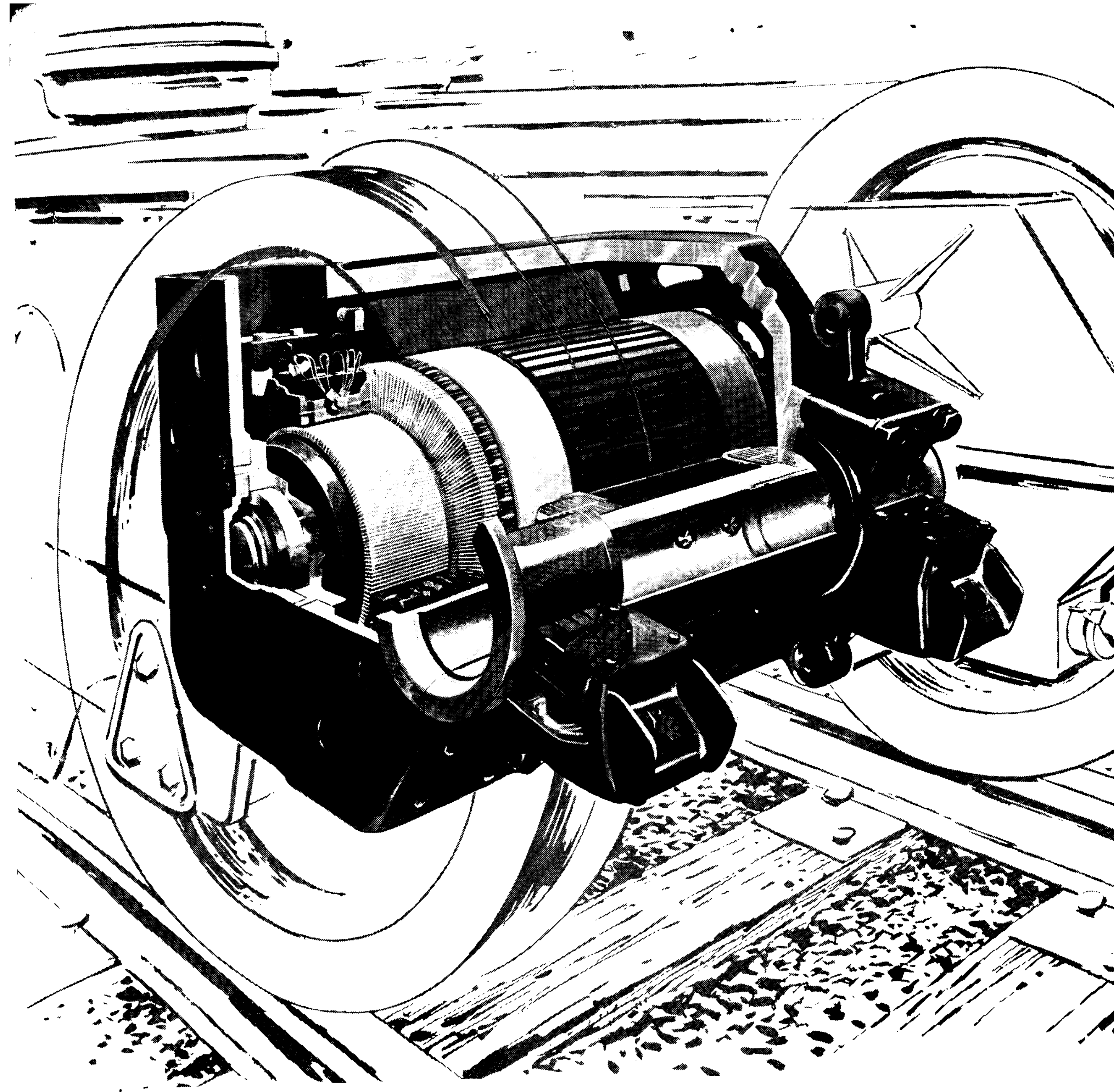
Last but not least is, apart from the wonderful engineering and architectural achievements, the town-ship breathes the life of modern India, where all the races and creeds of India are fairly represented in this gigantic project. The Punjabis, the Sikhs and the Kashmiris of North India live, eat, and play side by side and in close intimacy with the Bengalis and Biharis of the east, the Maharashtrians, Gujeratis and Konkinis of the West and South Indians from Madras, Andhra and Kerala etc. Here there is a heterogeneous mixture of races who live on amicable terms and enjoy the amenities provided by this vast enterprise and one never hears of any social discussions leading to any fight or quarrels. Further as their children will be growing up together in common schools, playing in common grounds they are bound to grow up as Indians first and last forgetting the narrow social boundaries which separate them one from another and at least in Chittaranjan the world can see the unity of India in its races, castes and creeds, all brought about in the one purpose of making India self sufficient in locomotive power.

BRITISH BUSINESS EXECUTIVE TO VISIT INDIA

Mr. J. O. de M. Hopper overseas representative of Expandite Ltd., London, is shortly to make an intensive tour of South Asia and the Far East, taking in India, Ceylon, Pakistan, Burma, Thailand, Malaya, South Viet-Nam, Korea, Hong Kong, the Philippines and Japan.

The visit follows the recent report by the Federation of British Industries' trade delegations on marketing possibilities in South-Asian territories.

Expandite, with subsidiaries in Australia, New Zealand, South Africa, Rhodesia and Ireland, refer to themselves as the firm who specialize in "Joints that move". They make joint fillers, sealing compounds, waterproofing compounds, bedding and metal casement compounds, glazing compounds, caulking compounds, rubber waterstops, anti-corrosion materials, concrete additives, fixing devices, mechanical appliances, and pressure guns.



An Important Announcement

★ We have great pleasure in announcing to all our Readers and Advertisers that we are incorporating the following Supplements as usual on various aspects of **RAILROAD ENGINEERING** in our **1962 ANNUAL NUMBER** to be released by the end of August 1962.

★ Advertisers desirous of buying advertising space in any one of the Supplements should intimate the fact to the Technical Editor (Advertising Branch) on or before 25th August 1962. We can accept only a limited number of advertisements due to space restrictions.

★ Technical articles or write-ups concerning Engineering Products would be published free of charge and twentyfive reprints would also be supplied without any charges. For other details please address your enquiries to the **Technical Editor, INDIAN RAILWAY ENGINEER, 15, Ghodbunder Road, Santacruz West, Bombay-54 (India)**

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TECHNICAL EDITOR

Test Runs with the Diesel Hydraulic Locomotive ML 4000 C'C' with Dynamometer Car

By An Engineering Correspondent

REASON AND OBJECT OF THE TESTS

THE 4000 H.P. locomotive designed by Krauss-Maffei for U.S.A. railroads is at present the world's most powerful diesel-hydraulic locomotive. It has been developed from the diesel-hydraulic six-axle locomotives of 2200 H.P. and 3000 H.P. built by Krauss-Maffei in the past years. In the same way as the preceding types, this locomotive has been subjected to exhaustive tests. The measuring tests were again carried out in cooperation with the German Federal Railway's Experimental Station, Experimental Test Department for Internal Combustion Engines, of Munich.

An essential novel feature of this locomotive is that it incorporates a first-time built hydro-dynamic brake attached to the hydraulic transmission in such a way that the two of them constitute a self-contained constructive unit.

EXECUTION OF THE TESTS

The test runs were carried out from March, 17th to 21st, and April, 19th to 23rd, 1961, on the line Munster-Emden. As braking load at the end of the test train two heavy goods train steam locomotives " Class 45 " for the speed range 0 — 80 km p.h. (0 — 50 M.P.H.), and for the speed range 80 — 110 km p.h. (50 — 86 M.P.H.) two express train locomotives " Class 184 " of the German Federal Railway used. The German Federal Railway prefers to use braking locomotives for measuring tractive efforts as only with this method is it possible to bring about such constant speed conditions as required for correct measuring. On gradients with their ever-changing track resistances, such favourable conditions are quite exceptional. The braking locomotives with their controlled counterpressure enable precisely adjusted brake effort constants to be achieved through-out the entire speed range. The track Munster-Emden is especially appropriate for the tests under consideration as it runs over flat land with but slight differences of level and few curvatures.

The train used for testing consisted of one diesel-hydraulic locomotive ML 4000 C'C', one dynamometer car, one by-car, one equipment car, and the two braking locomotives, in each instance.

In the direction Munster-Emden, the tractive efforts of the locomotive were measured, and in the opposite direction the braking efforts, the steam locomotives serving as braking locomotives in the one direction, and as traction engines in the other.

Tractive effort at draw hook (Zh) was ascertained by means of a measuring member fixed between the loco-

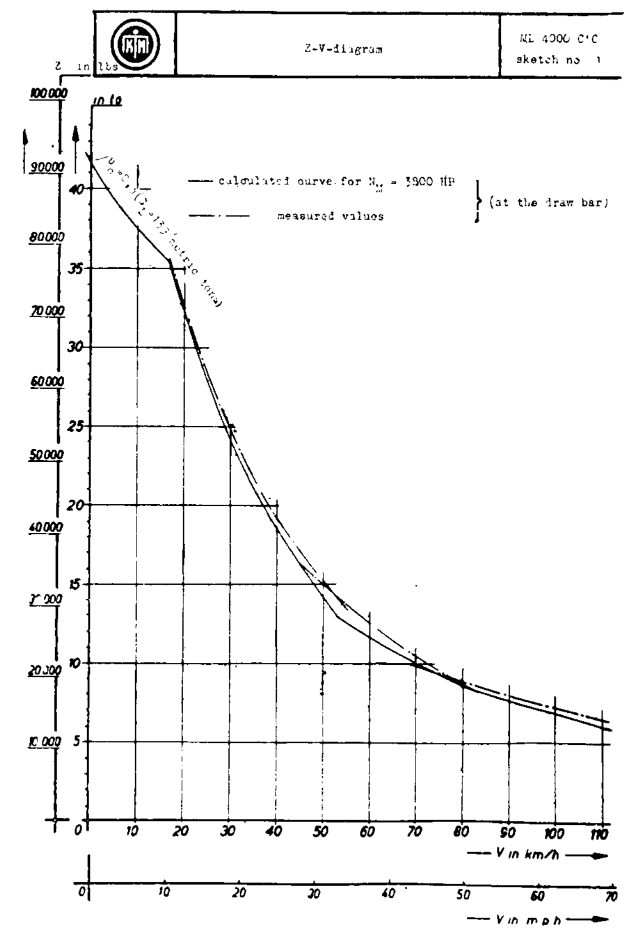


Fig. 1 Tractive effort/speed diagram comparing the theoretical with the measured effort at draw hook

motive and the dynamo-meter car, and it was recorded by an electronic compensator. Elongation meter strips served as transmitters reacting to every elongation of the draw spindle as caused by the traction force in such a way that their ohmic resistance is being changed in proportion to the acting force. The running speed V was measured by means of an A.C.-tacho-generator attached to one of the axles of the dynamo-meter car, and recorded by a voltage-sensitive compensograph. Fuel consumption of the two diesel-engines was gauged by a piston type counter and recorded through electric transfer lines by counting relays located in the dynamo-meter car.

Pressures in the main and secondary circuits of the hydrostatic of the cooler fans were measured by means of pressure cells and recorded in a 12-point recorder. The speed of the diesel engines were further recorded and all important temperatures of air, water, and oil were taken in two 12-point recorders.

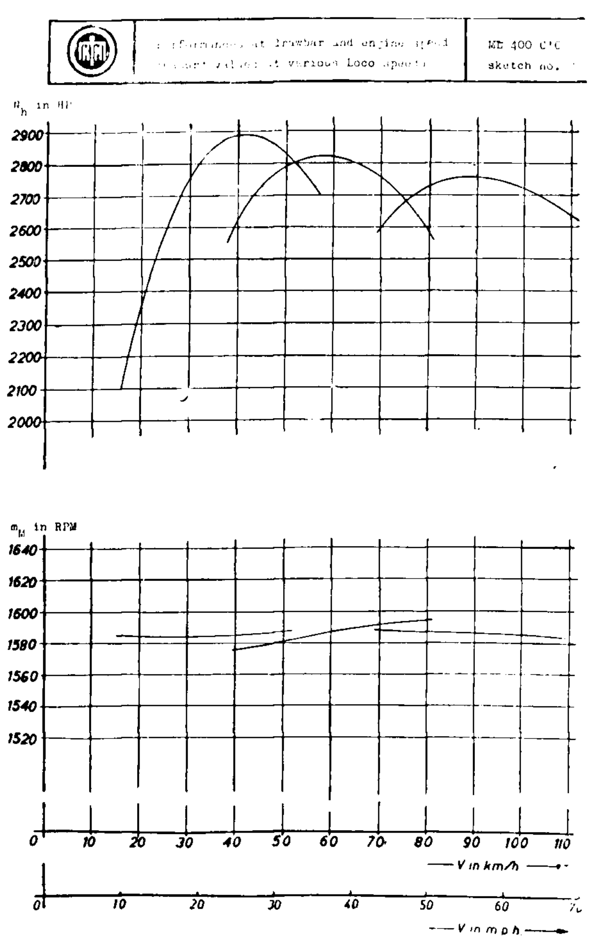


Fig. 2 Measured values of effort at draw hook and engine speed in relation to locomotive speed

RESULTS OF THE TESTS

Fig. 1 is a tractive effort/speed diagram in which the measured tractive efforts at a draw hook are compared with those which had been previously calculated. When comparing these two graphs, allowance must be made for the fact that the calculated values apply to a diameter of half-worn wheel tyres, but the measured ones, of course, to new tyres. Consequently, even if the two graphs did not exactly coincide with each other, this would prove the measured tractive effort to be higher than the pre-calculated one. Either diesel-engine was adjusted to 1,900 H.P. at 1,580 RPM.

Fig. 2 shows the measured effort at the draw hook and the engine speed as a function of the running speed. This graph makes evident that there occur but little steps at the change-over points from converter to converter, and that engine speed remains almost constant at these points.

Fig. 3 illustrates the brake efforts obtained by the hydro-dynamic brakes of both power plants. As this

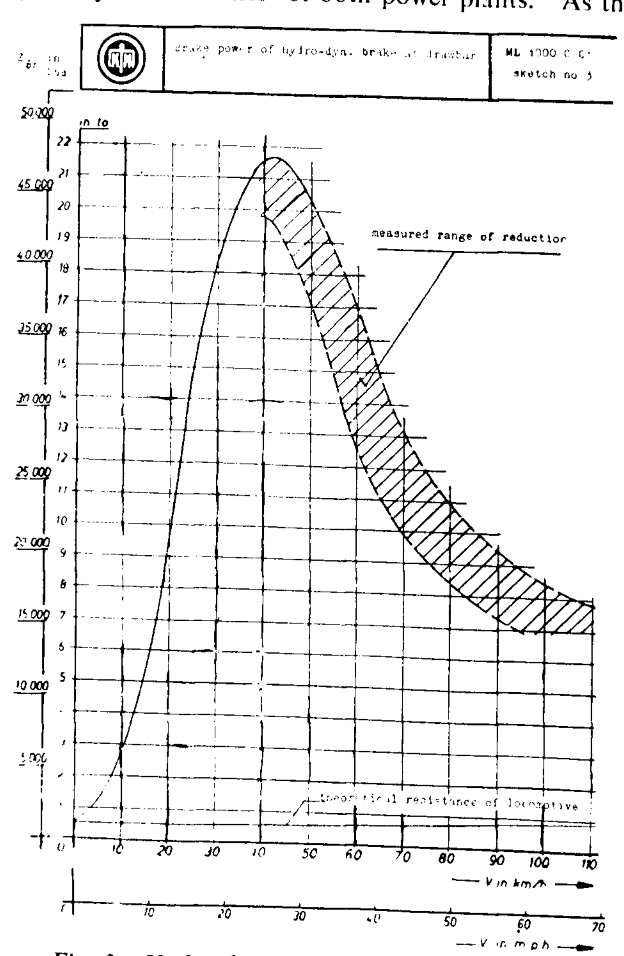


Fig. 3 Hydro-dynamic brake
Brake effort measured at draw hook

graph includes the running resistance of the locomotive, the latter has to be substracted ; its values are registered at the lower part of the diagram. The curve showing the measured values is a steep parabola rising in conformity with speed increase, which corresponds to the characteristics of hydraulic couplings. The whole realized brake effort is transformed into heat which has to be dissipated through heat exchangers and coolers the capacities of which put a limit to the available brake power. The actual cooling capacity corresponds to an output of 1,400 H.P. of each engine as expected to be available at site, viz. 50° C (122° F) of ambient temperature. For these reasons, tests with varied brake effort adjustments were carried out in the critical cooling range in order to have these thermic limits precisely checked.

Fig. 4 reproduces measurings of the tractive effort at the start. In order to obtain exact test values, every

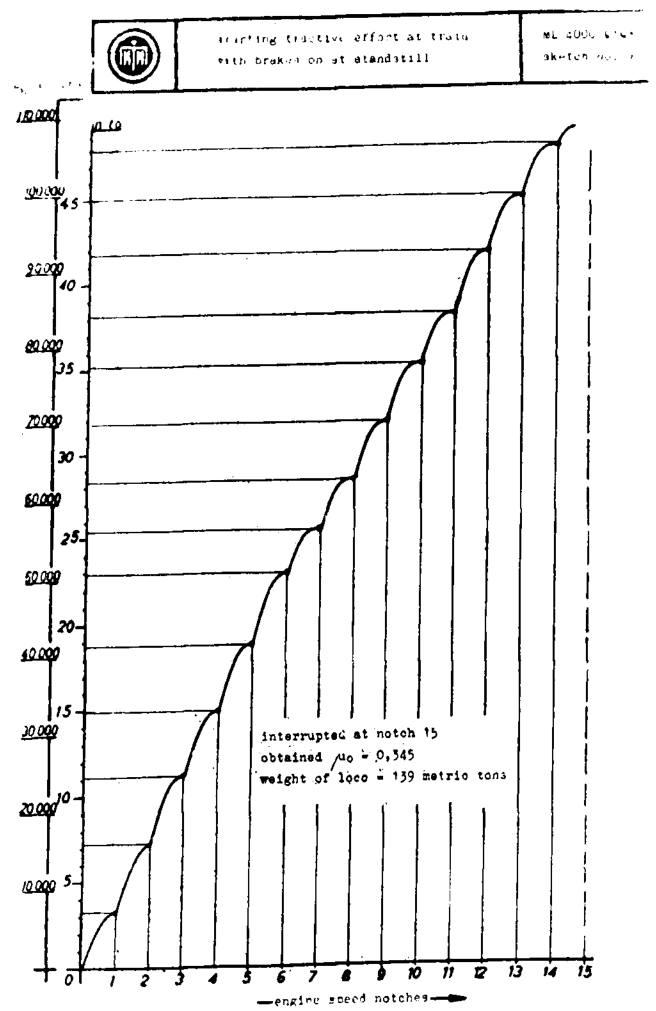


Fig. 4 Tractive effort at start measured with braked train

change-over from speed step to speed step was made only after a state of permanent speed had been accomplished. To this effect, the test train was braked and the brake of the diesel-hydraulic locomotive released with the independent air brake valve. During this test, which lasted for 2 minutes and 34 seconds, no thermic overstrains occurred.

SUMMARY

The tests have given unambiguous information about the performance of the diesel-hydraulic locomotive ML 4000 C'C'. In particular, they proved the consistency of the measured values with the calculated ones, and that in some cases the latter exceeded. Worthy of emphasis are the unobjectionable and smooth running of the locomotive over the whole speed range and the extraordinarily low noise level inside the cab.

When the hydro-dynamic brake was tested, one of the most impressive occurrences was that two of the heaviest German goods trains locomotives were unable to accelerate the train to speeds exceeding 30 km/h (19 M.P.H.), against the braking power of the hydraulic locomotive. It may be mentioned in this connection that, when the efficiency of the hydro-dynamic brake was being demonstrated, the test train, weighing 650 metric tons, was almost brought to standstill from a speed of 80 km/h (50 M.P.H.) over a horizontal distance of 800 meters (875 yards), although this brake is intended to be used on slopes only.

In conclusion, it may be affirmed that the thorough test runs carried out by the German Federal Railway's Experimental Station, Experimental and Test Department for Internal Combustion Engines, of Munich, have proved the measured values to be fully in accordance with the calculated ones.

DIESEL-HYDRAULIC LOCOMOTIVE TYPE ML 4000 C'C'

MAIN DATA:

Drawings :

View	M 1.03—79
Sections	M 1.04—45

Output diagrams :

Tractive effort/speed diagram	M 6505 b

Gradient/speed diagram (4 locomotives and goods train, 3830 sh. ts.)	M 6508 b

Engine output (to U.I.C., i. e. at altitude of 655 ft. = 200 m, and temperature of 68°F = 20°C) 2 × 2000 H.P.

Engine output at site conditions :

Altitude ab.sea-level ft.	Temperature °F	Continuous engine output H.P.	Input into hydraulic transmission with average load of auxiliaries H.P.
1,310	86	2 × 1900	2 × 1770
or 2,620	68		
or 3,940	50		
1,310	104		
or 2,620	93		
or 3,940	77	2 × 1800	2 × 1680
or 5,560	54		
or 6,890	32		
1,310	122		
or 2,620	111		
or 3,940	97	2 × 1700	2 × 1600
or 5,560	82		
or 6,890	64		
or 9,190	32		
5,560	100		
or 6,890	86	2 × 1600	2 × 1500
or 9,190	54		
or 10,170	36		

To description ML 6849

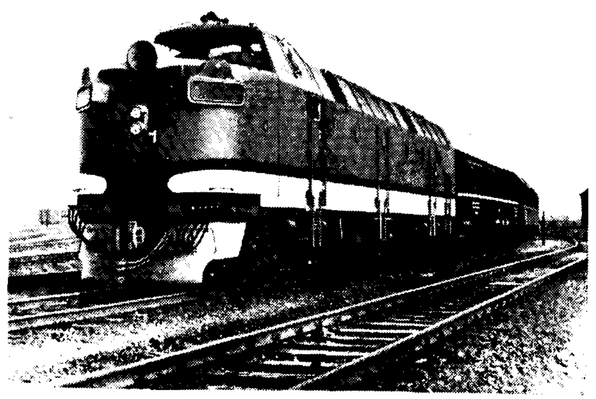
MAIN DIMENSIONS

Gauge	4′-8.1/2″
Diameter of driving wheels	40″
Wheel base of the bogies	11′-5.3/4″
Total wheel base	49′-9.1/2″
Distance between bogie centers	38′-3.11/16″
Axle load, approx.	27.6 sh. ts.
Weight in working order, approx.	165 sh. ts.
Weight empty, approx.	145.5 sh. ts.
Overall length, incl. couplers	65′-11.5/16″
Maximum height	15′-6.3/16″
Maximum width	10′-8.15/16″
Maximum speed	70 m.p.h.
Minimum radius of curves	250 ft.
Fuel tank capacity	3.280 U.S.A. gal.

DIESEL-HYDRAULIC LOCOMOTIVE TYPE ML 4000 C′C′

Gradient/speed diagram (1 locomotive with goods train 875 metr. t)	DM 6840
Engine output (blocked according to site conditions on Semmering line)	2 × 1900 H.P.
Owing to service conditions and loading gauge of the OBB (Austrian Federal Railways) the following measures and weights have been changed :	
Axle load, approx.	25.4 sh. ts.
Weight in working order approx.	152 sh. ts.
Overall length, incl. buffers	71′-2.7/8″
Maximum height	15′-3″
Maximum width	10′-3.5/8″
Fuel provision	660 U.S.A. gal.

(To Description ML 6849 only for demonstration run on Semmering)



Diesel locomotive ML 4000 C′C′ for USA : Locomotive arranged before the dynamometer car of the Deutsche Bundesbahn

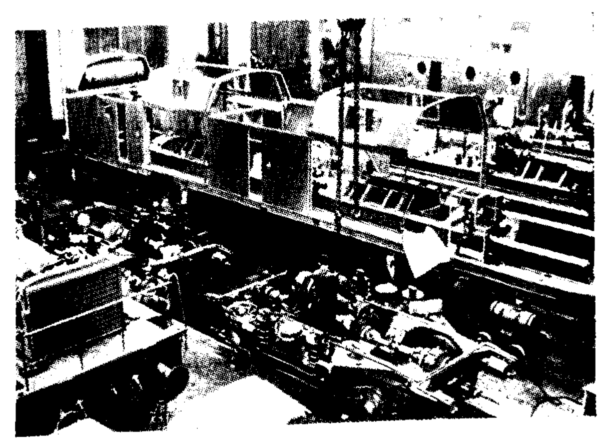
Description of the Diesel-Hydraulic Locomotive ML 4000 C′C′

GENERAL

THE locomotive described hereafter is the world's first single-unit diesel locomotive designed for an installed rated power of 4,000 H.P. It puts a provisional end to a consistent development which includes such well-known diesel-hydraulic locomotive types as the V 200, the ML 2200 C′C′-Yugoslavia, the ML 2700 C′C′-Turkey, and the ML 3000 C′C′.

Like all these locomotives, it has its drive system split up into equal power groups each of which acts by means of cardan shafts on the three axles of the bogie next to it. Owing to the special operating conditions of the U.S. railroads, the outer body of the locomotive and its equipment differ, however, in some points from former standards. The most conspicuous difference concerns to the cab arrangement as there is only one end cab whereas the opposite end is formed just by the truncated locomotive body. This " A-Unit " design, typical for units which are mainly being used in multiple traction, enables the two cooler plants to be located asymmetrically (as seen from side) in order to shorten the locomotive. What further contributes to its shortening is that there is no heating boiler required as the unit is to be used chiefly in goods train service.

As the locomotive is intended to operate in the mountainous lines of the Denver & Rio Grande Western and Southern Pacific Railroad Companies, it has been equipped with hydro-dynamic brakes in order to spare brake-shoes on down-hill runs. This hydro-dynamic brake is a full equivalent of the dynamic brake used in the rivalling diesel-electric locomotive.



Diesel locomotive ML 4000 C′C′ for USA : Superstructures and bogies in course of erection.

Like the " A-Units " usually built according to U.S. standards, the present locomotive is protected by a ram-like reinforced projecting part set before the cab, but unlike those, it features a broken roof line as the roof of the engine room is lower than that of the cab. This has been done with a view to the convenience of having some free space left over the exhaust stacks with the result that the temperature of the drawn-in combustion—and cooling air is lower in narrow tunnel passages Incidentally, this also permits the exhaust gases to be watched through small roof windows while the locomotive is running. The fact that the upper parts of the side walls show an inward inclination is due to the loading gauge conditions prevailing in the European railroad lines where the locomotive has to be tested first, but in spite of these tests the gauges have been exceeded. In addition the axle loads, of course, exceed European standards as a result of larger general dimensions, considerable fuel provision and, last but not least, the heavy adhesion weight of the locomotive which is required to match the tractive forces incorporated in it.

POWER PLANTS

Either power plant consists of :

1. One *Maybach diesel engine, type MD 870*, 16 cylinders in V-arrangement, 4-stroke, with pressure charging and intercooling of the charging air. Engine output at 20°C = 68°F and at 736 mm Hg = 14.23 pounds (Av./sq. in. of mercury) : 2,000 H.P. at 1,585 r.p.m. The engine rests on vibration dampening rails fitted on the main frame.

2. One *three-converter Voith turbo-transmission, type L 8-30 rU*, with built-in reversing gear and unilateral bottom-sided power take-off. The transmission rests on the main frame by means of two rear vibration dampening rails and two front silent blocks. Attached to the transmission there is the hydro-dynamic brake (see : " Brake ").

Diesel locomotive ML 4000 C'C' for USA: Frame and view from above

3. One *intermediate gear, make: Krauss-Maffei,* consisting of a pair of enclosed spur gears, with unilateral top-side power take-in and two-side power take-off underneath, resting on the bogie.

4. *Three Maybach bevel-gear axle-drives, type C 33 vl,* combined with spur-wheel gears.

The mentioned drive elements are connected with each other by means of cardan shafts in such a way that an elastic coupling is interposed at the engine flywheel and that the shaft arrangement yields the highest possible geometrical effect. The attached type drawing M 1.04–45 shows the total drive layout in resume.

DETAILS OF DRIVE ELEMENTS:

1. The diesel engines are *started electrically.* For this purpose, there is a starter-dynamo fixed on either Voith transmission, which is rigidly connected by means of elastic coupling and a gear-wheel step to the drive shaft of the hydraulic transmission and thus to the diesel engine.

2. The *combustion air* for the engines is drawn in over plate-type and oil-bath filters through openings in the side walls of the body.

3. The exhaust gases of the engines leave the locomotive by the shortest possible way via the roof of the machine room.

4. The *fuel* is stored in two large tanks located one after the other under the main frame between the bogies. The fuel is pumped electrically into the injection devices of the engines. On the way, the fuel can be pre-heated, if necessary.

5. *The engine coolers* are suspended, independently, from above into the body, as complete and self-contained units designed in V-section. The cooling air is drawn in through lateral louvers which can be closed, and is blown upwards. The cooling fans are driven hydrostatically in such a way that each of the two main engines drives two multiple-piston oil pumps which are connected to the pressure oil motors of the pertaining three fans by means of V-belts, via a pressure line. Oil pressure is related to the cooling water temperature and is regulated automatically by means of a thermostat and a by-pass. The cooling water flows in one main circuit through the cooler, the engine housing, and the heat exchangers for transmission oil and engine lubrication. A secondary circuit which cools the charging air exclusively runs through a separate block group. The third fan acts simultaneously on this secondary circuit and on a small section of the main circuit.

6. Each power plant is provided with a *preheater* designed as an oil-heated apparatus through which the cooling water runs.

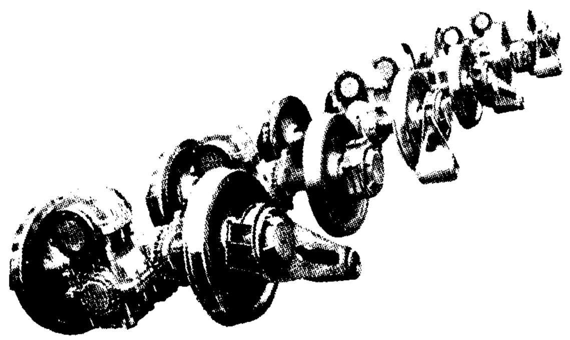
7. To improve the cooling effect in narrow mountain tunnels which have become heated by exhaust gases, each cooler is equipped with a *water spray device* embodying a row of downward spraying nozzles fixed outside the upper end of the cooler. Through these nozzles, one in front of each cooling block joint, a curtain of water particles is sprayed before the entire cooling surface by means of electrically driven pumps. The spraying water is stored in a tank placed at the rear wall of the engine room.

FRAME

The frame consists of two continuous wide-flanged I-section girders connected by several sturdy cross members. These members are fabricated blocks in the locomotive center either beneath the diesel engines and above the bogies, whereas either end member is formed by cast-steel pieces which at the same time contain pockets for the central couplers. The running boards are fixed by brackets to the outer of the main girders, about midway their web. All frame parts are welded together electrically so as to form a solid structure of sufficient stiffness to resist without lasting deformation when at the same time vertical loads occurring under normal service conditions, and buffer pressures of 1,000,000 lbs. i.e. 454 metric tons.

The draw and buffer gear used is the central coupler AAR, type E, with provision for adjustment and with draw gear type M-380. Rods for releasing the coupler claw are underneath and are manipulable from either side.

Finally, there is a sheet-steel pilot screwed to the front end of the frame.



Diesel locomotive ML 4000 C'C' for USA: Wheel sets of the two bogies

Diesel locomotive ML 4000 C'C' for USA: View of erection shop

RUNNING GEAR

The frame rests on the two bogies in four points, each of which is situated far outside the wheels and in the transverse planes intersecting the centers of the two bogies. With the symmetrical arrangement of the wheel bases this results in a plain load distribution and complete uniformity of the bogie ride in forward and backward directions.

The general arrangement of the welded bogie is explained in the attached special description (ML 6600) accompanied by schematic drawings (ML 6594). More constructive details are shown in the photographs which are likewise included.

SUPERSTRUCTURES

The superimposed box consists of four sections out of which the hood and the two machine room sections are firmly bolted to the frame, whereas the cab sections rests on rubber cones. The weather-resistant and insulating connection of the sections with each other is made by means of rubber profiles.

All of the four superstructure sections are completely welded self-contained structures consisting of a frame of folded sectional steel onto which the outer walls are spot-welded. For noise insulation, the inner sides of the walls of the two machine rooms are covered with sprayed-on anti-noise material.

As against this, the cab is double-walled and noise and heat insulated all over by filled-in stone wool. Internally, it is covered with perforated sheets. There are lids in the cab floor and roof through which the cardan shaft between engine and hydraulic transmission can be removed. The front starter-dynamo can be dismantled through a lid in the hood roof. For taking out the hydraulic transmission the whole front hood has to be removed. At the right cab side, there are further detachable wall sections granting access to the brake accessories. For the diesel engines, detachable roof sections of suitable size are provided in the superstructure. The complete cooler plants inclusive of the louvers, fans, and stacks are hung in the form of large boxes in opening of adequate dimensions situated in the two engine room sections. The rear hydraulic transmission can be taken out through the roof opening which results from removing the rear cooler plant. The engine room may be entered from both sides through a side door by means of steps, and entrance into the cab is also made through a side door. From the cab two doors in the backwall lead to the running boards at either side of the machine plants. A door on the left of the cab's front wall leads to the front hood, and finally it is possible to pass from locomotive to locomotive through a door in the middle of the front wall.

Day-light enters the engine room through thirteen round windows in all in the side walls and in the rear wall.

The engine room is ventilated by two fans drawing in air over sheet stacks from the louver areas of the front coolers. After having passed plate-type filters, this air is blown towards the finned pipes of the inter-coolers provided for the brake air compressors.

In the right-hand corner of the rear engine room, there is a W.C. which receives its water from the already mentioned water tank feeding the water spray device. For this purpose, the water tank is partitioned.

CAB EQUIPMENT

The cab set back from the front end by the length of the front hood and raised as much as possible within the given loading gauge, offers an excellent visibility to the front and the sides. Above the two side doors provided with slide windows are fixed windows and next to the latter but further forward and separated from them only by a narrow bar are the large side windows, the rear sections of which are constructed as push windows. The two large front windows are provided with pneumatic windscreen wipers, de-frosters and four sun visors in all which are adjustable by hand. Above the front widows, there are air flaps regulable by hand. As already mentioned, it is possible to watch the engine exhaust gases through the two fixed windows in the rear roof slope. Through the same windows the daylight falls onto the steps leading from the entrance doors to the platform.

Side-by-side on this platform are fixed three upholstered and independently adjustable seats provided with arm and back rests. In front of the right-hand seat, the complete operating equipment needed by the engineer is arranged in an easy-to-reach location. This equipment comprises a table in the middle carrying the most important pressure gauges for brake and control as well as the warning lamps and electrical switches; further to the left of the table is a control column with the master controller for driving and the hydraulic brakes, the reverser with the pertaining telltale lamps and the recording speedometer; and finally to the right of the table next to the side wall is the brake columm with the engineman's brake valves and the levers for sanding and bell ringing.

In the middle under the front windows is located an air conditioning apparatus, make: Hornkohl & Wolf, Bremen, as needed for cab heating and ventilation and de-frosting of the front windows. This device draws in the air through the front hood roof and is heated up by the cooling water optionally from power plant I or II. There is finnlly to the left of this apparatus a stand with a drinking water cooler.

DRIVE CONTROL

All control operations for driving, inclusive of the inherent impulses are carried out pneumatically.

1. The installed compressed air control system comprises the following direct control operations:

   1.1 *Partial filling of converter*, at step 1 of the controller, renders possible slow and sensitive travelling movements of the locomotive in single traction.

   1.2 *Operation of filling valves* of the hydraulic transmission, at step 2 of the controller. In this step, the start converters of the the transmissions are filled up to normal load run readiness. The engines continue running idle

   1.3 Engines output control, at steps 3 to 17 of the controller, corresponding to travelling steps between minimum to full load output of the engines.

   1.4 *Reverse gear operation*, with the positions "forward" or "backward" of the reverser.

   1.5 *Hydro-dynamic braking*, with the brake steps 1 to 8 of the controller.

2. The compressed air control system further comprises the following indirect control operations:

   2.1 Safety control to supervise the engineer.

   2.2 *Overload protection* attained by pneumatic interdependance between engine control pressure and brake cylinder pressure in such a way that the engines cannot be brought to maximum output as long as the locomotive is being braked.

   2.3 *Other locking and Switch-off devices* to counteract operational mistakes.

3. To ensure a faultless operation of the locomotive, a further number of supervision and safety devices have been installed, which are either electrically or electro-pneumatically controlled, as is most expedient. In this connection reference is made to the wheel slip protection comprising an electric transmitter and a magnetic valve, and further to the various control and indicator lamp circuits and similar provisions which in the last analysis complete the purely pneumatic controls as already grouped under 2.3.

4. The tasks the locomotives are expected to perform render indispensable an operation in *multiple traction*. Therefore, all those provisions have been made which enable several locomotives of equal type to be operated from one cab. To this purpose, the locomotive has been equipped, with the necessary piping safety and control devices, and the easy-to-handle tube and cable couplings needed for connecting the units at their ends.

The front hood houses a frame containing all of the pneumatic control devices.

At the right of the engine room, near the passage way, a switch cabinet contains the most important electric devices. At either side of this cabinet are located those measuring gauges and indicator lights controlling the machine plants which the engineer must continuously watch.

BRAKES

The locomotive is provided with the *Compressed Air Brake Equipment 26 L of the Westinghouse Air Brake Company*. The compressed air is produced by two separate equal plants. Each of the two diesel engines drives from its free end, turned towards the locomotive middle, a three-cylinder compressor type 3CDCB over V-belts. Each compressor has a capacity of 225 cubic feet per minute, i.e. 378 cubic meters per hour, at 1000 r.p.m. Both compressors feed the two main air reservoirs situated in the middle of the locomotive. Besides the brakes these reservoirs which have a total capacity of 800 litres, i. e. 48,820 cubic inches, supply with compressed air the pneumatic control equipment and the air-operated accessories such as sanders, acoustic signals, windscreen wipers, etc.

On the the operation desk in the cab are the two engineman's brake valves for automatic and direct brakes, and further the pertaining pressure gauges.

All wheels of the locomotive are braked on both sides, for each wheel a brake cylinder is provided.

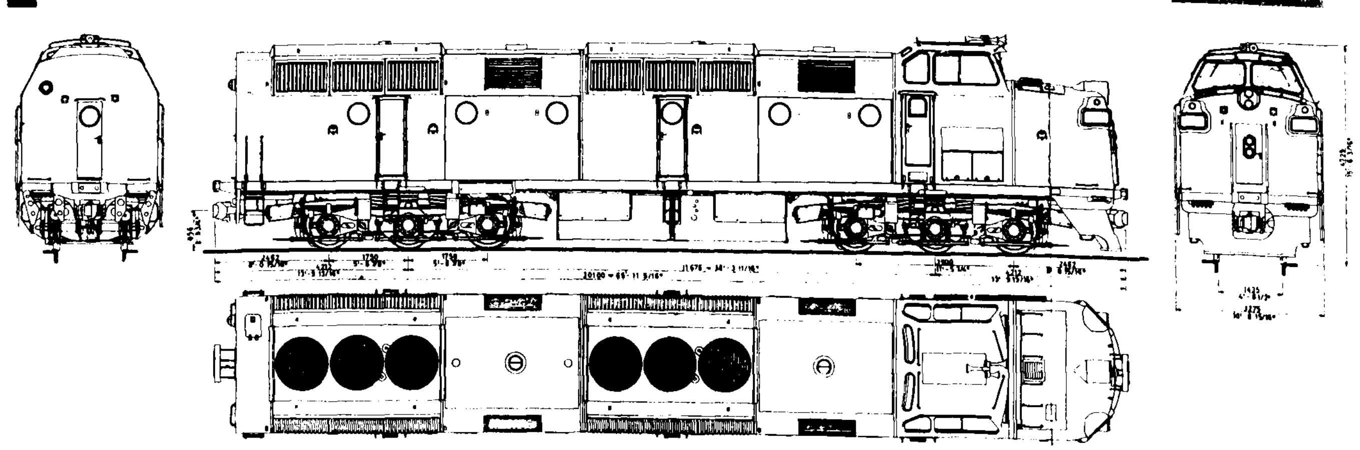
The *hand brake* only acts on the two brake shoes of one wheel of the central axle of the front bogie. It is a spindle brake with chain transmission operated by a handwheel fixed to the rear cab wall.

To reduce the wear of brake shoes on long downhill lines the locomotive is equipped with two *hydrodynamic* brakes. Each one of these brakes is attached as a self-contained unit to the secondary side of either Voith transmission. It consists of a hydraulic coupling circuit which admits variable filling. By controlling this filling pneumatically by means of the master controller, the braking effect can be raised in 8 steps up to a maximum or reduced inversely.

The master controller serves for initiating both the drive and the brake operations : for driving when its crank is moved from its zero position towards the engineer, and for braking when moved in the opposite direction.

The heat produced in the brake circuit is led off over the brake heat exchanger to the coolers whose cooling

KRAUSS-MAFFEI AKTIENGESELLSCHAFT MUNCHEN-ALLACH



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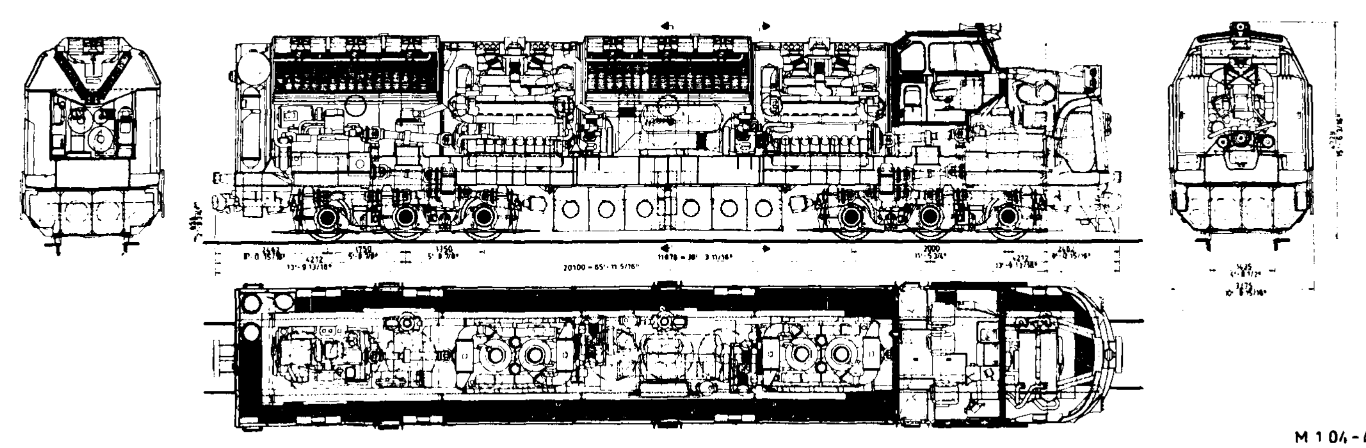
KRAUSS-MAFFEI AKTIENGESELLSCHAFT MUNCHEN-ALLACH ML 4000 CC



M 104-45

capacity is largely available as on down-hill runs they have only to eliminate the heat of the idling engines.

A special safety device reduces automatically the filling of the brake circuit and thus the braking effect whenever there is a danger that the maximum admissible braking power, which is limited by the cooler capacity, is going to be exceeded.

OTHER EQUIPMENT

(a) *Electrical equipment*

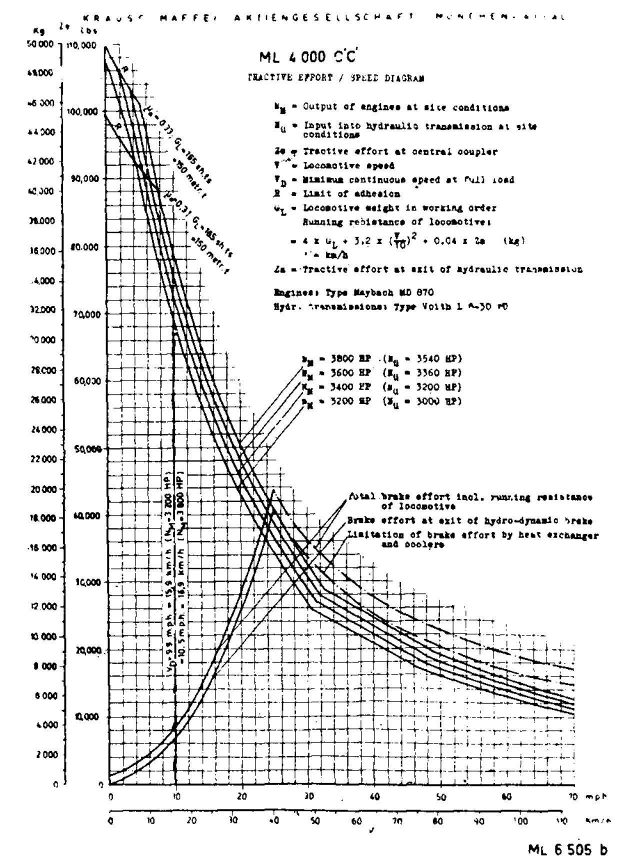
A lead battery is placed on both sides of the locomotive in each of the two outer recesses of the fuel tanks. At an operating voltage of 64 V it has a capacity of 385 Ah referred to 5 hours discharge). While the locomotive is working, the battery is continuously charged from the starter-dynamoes mentioned under III.1 and supplies the current for starting the engines, for the control circuits, for minor electrical auxiliaries, and for the lighting. The lighting equipment covers the cab, engine room, and instrument lights, the large warning lights on the front hood and, beneath it, the dual sealed beam headlights, the train number lights, and a hand lamp with cable for which several wall sockets are provided.

(b) *Sanders*

Each four spacious flat sand boxes which can be re-filled from outside through hatches, are welded to either inner longitudinal side of the superstructure. The sanders are pneumatically operated ; sand is discharged in front of the leading wheels of either bogie. In connection with the wheel slip protection, sanding takes place automatically as soon as slipping begins.

(c) *Warning signals*

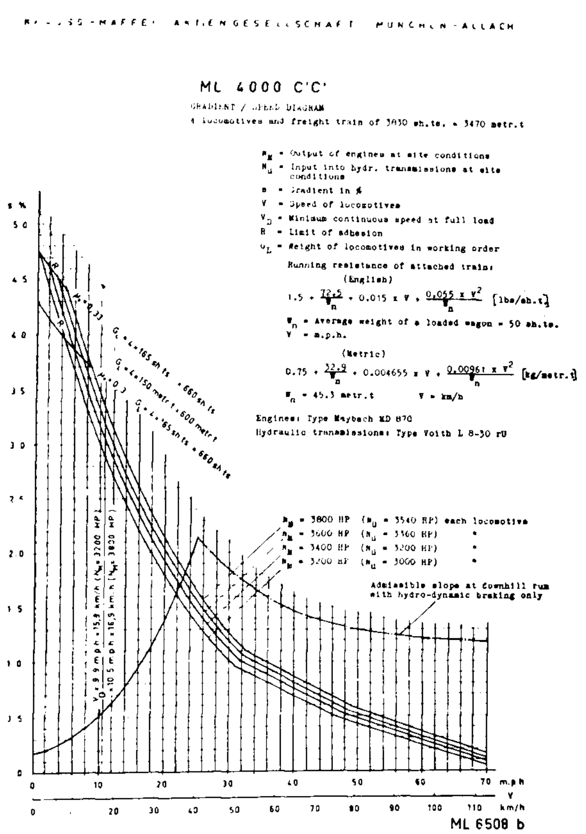
A pneumatic three-horn-typhoon is applied on the roof of the cab. It is operated by



means of two cable pulled valves, one for normal volume of sound and the other for full intensity. Furthermore, an air-operated bell is placed on the frame, behind the pilot.

(d) *Fire extinguishers*

One fire extinguisher each, of U.S.A. make, is kept at easy-to-reach places in the engine room.



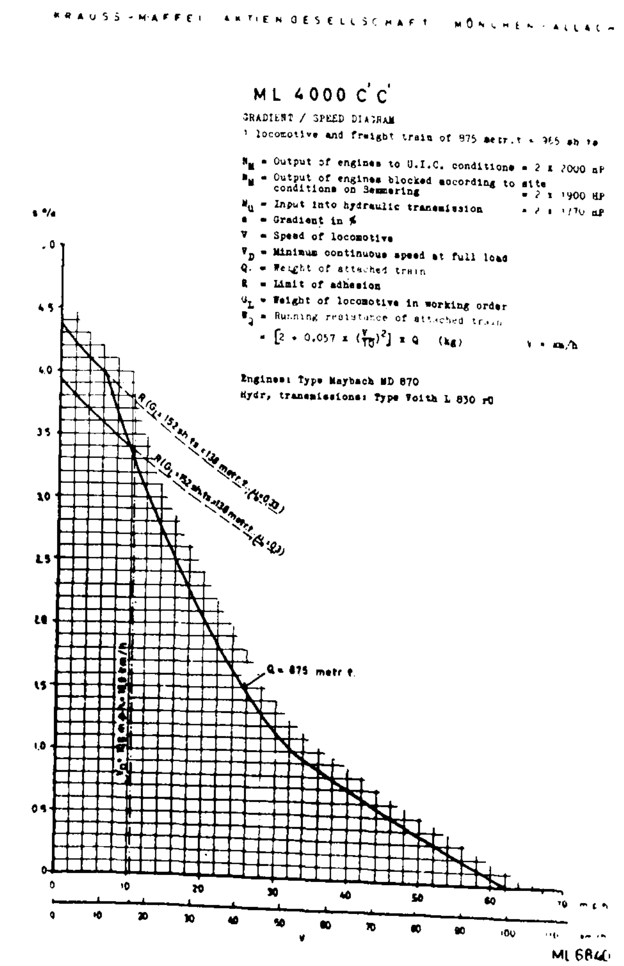
THREE-AXLE BOGIE OF KRAUSS-MAFFEI DIESEL LOCOMOTIVE

This novel bogie design, an all-welded box-type construction, differs substantially from the conventional bogie layouts :

(1) Its general arrangement is adapted to the special conditions imposed by Cardan shaft drive :

(2) Its riding qualities are improved ;

(3) Its wear in operation and consequently its maintenance costs have been substantially reduced.



1. The conventional pivot connecting the bogie with the main frame is replaced by a lever and rod system (16) fixed partly on the bogie frame (10) and partly on the protruding main frame extention (2). As a result, the longitudinal centre lines of bogie frame and main frame always intersect in one point, the ideal pivot of the bogie. Silentblocs warrant little wear and protect against any play which otherwise would have a detrimental effect on the steadiness of the running locomotive. On the other hand, these elastic joints are dampening lateral shocks and are increasing the centering force.

The pull and brake forces acting in longitudinal direction are transmitted from the bogie to the frame by manganese hard steel liners (11).

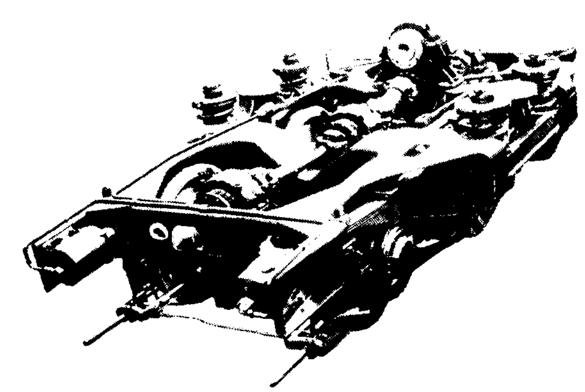
An intermediate gearbox (17) firmly connected to the bogie frame allows the use of short

Cardan shafts between the flanges of the off-drive shaft of the hydraulic gear and the axle drives. Torque supports and their suspension elements provided with rubber blocks transmit the torque reaction of the axle drives to the main frame where it is taken up.

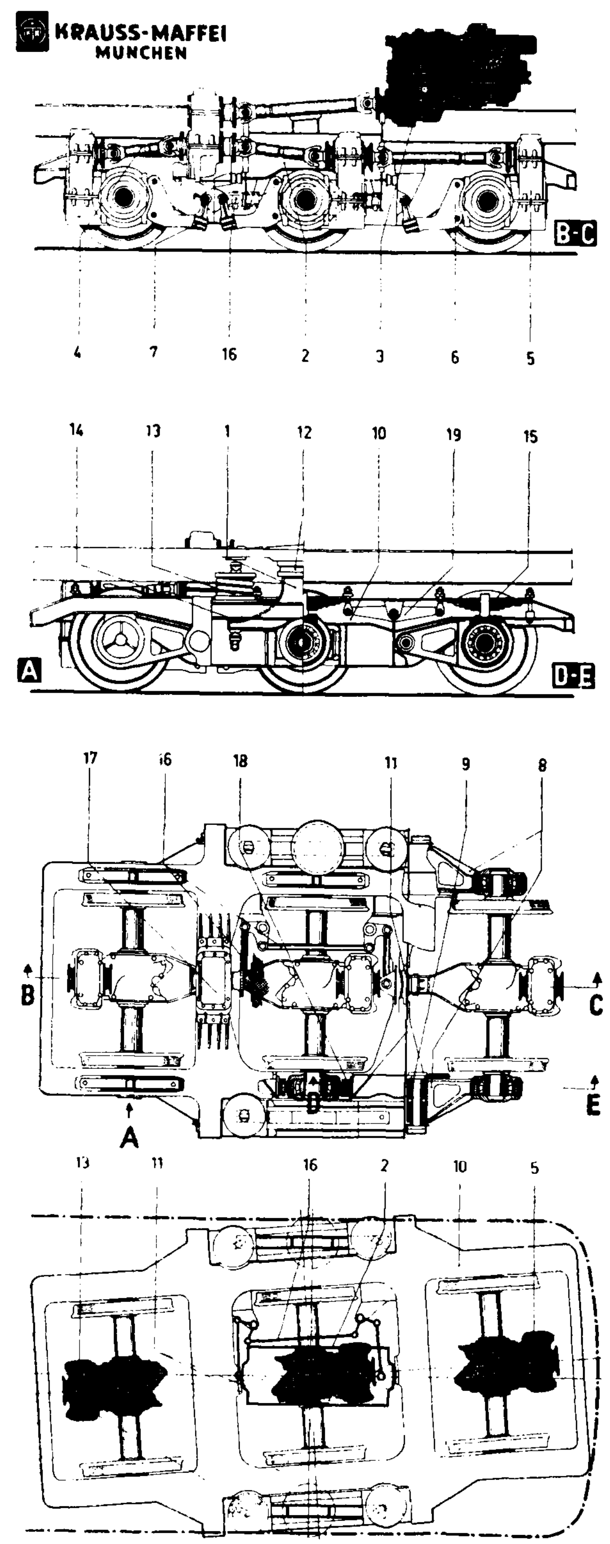
2. The rigidity of the box-type welded axle guiding links (8) which are hinged by means of rubber blocks (9) warrants *invariably* good running characteristics of the locomotive on the track as well as an elastic absorption of lateral shocks occurring on the wheel flanges. In a similar way, the rubber lined joints of the lever and rod system dampen the undesired vibrations of the bogies, i.e. veering and hunting.

The vertical loads are transmitted from the main frame to the wheels in two steps. The frame rests by means of rubber bolsters (12) on 4 cross members (1), and these are suspended in turn by spring tensioning screws (14) and helical springs (13) in the cantilevers of the bogie frame. The broad basis of this soft suspension results in a stable position of the locomotive superstructure also on uneven track, i.e. it prevents excessive rolling. The same effect is attained by a higher rigidity of the direct springs (15) between the axles and the bogie frame (10) taking into account the narrower basis of these direct springs.

The direct suspension of the main frame in the cross members on both sides and the pendulum suspension of these in the long



Diesel locomotive ML 4000 C'C' for USA : Three-axle bogie



tension screws (14) and helical springs (13) has at the same time a centering effect in case of the bogie being out of the centre line, thus counteracting against veering and hunting. When the bogie is swinging these tension screws take up the displacement between main frame and bogie by a corresponding inclination in the same way as this is done by the Cardan shafts in power transmission.

The spherically shaped heads of the spring tensioning screws (14) under normal conditions do not touch the corresponding stop faces of the main frame. They are intended to serve as emergency support in case of the breakage of a spring.

3. The wheelsets with their small wheels and comparatively light axle drives (5) do not strain very much the track nor—as a consequence—themselves. They run in self-aligning roller bearings which are carefully sealed and thus guarantee great mileages without any attendance. In order to avoid guiding friction surfaces the axle bearings are fitted in axle guiding links (pendulums) (8) which are connected to the frame by rubber joints (9) and allow for elastic swinging. These rubber joints do not require any attendance.

The axle drives are sealed oiltight. Experience has shown that Cardan shafts may remain unattended for longer periods of time. Since also the manganese hard steel liners (11) do not require any lubrication during normal operation, there is no need for the otherwise irksome manipulation with oil can and grease gun between and underneath the bogie frame. Thus only a few easily accessible joints of the brake rods and the spring suspension arrangement will require some drops of oil, from time to time.

Needless to say that such a reduction of wear will result in a corresponding decrease of maintenance costs.

THREE-AXLE BOGIE OF KRAUSS-MAFFEI DIESEL LOCOMOTIVE

(1) Cross member between springs
(2) Projection of the main frame
(3) Hydraulic transmission gear
(4) Cardan shaft
(5) Axle bevel drive
(6) Torque support
(7) Suspension elements of torque support
(8) Axle guide pendulum
(9) Silentbloc for axle guide pendulum
(10) Bogie frame
(11) Pressure pieces of manganese hard steel
(12) Rubber bolster
(13) Helical spring for secondary springing
(14) Spring tensioning screw
(15) Laminated axle spring for primary springing
(16) Guide linkage
(17) Distributing gear
(18) Axle-box liners
(19) Equalizing beam

The share of diesel-hydraulic locomotives in the total number of diesel locomotives and the share of Krauss-Maffei locomotives in the total number of high-power diesel-hydraulic locomotives, in the world

At the present moment, there are some 54,000 diesel locomotives powered with more than 200 H. P. of all types and classes in service or under construction in the Western World.—sufficient data for the Soviet Union and Eastern Block states are not available.

Of these 54,000 diesel locomotives, about 9,000 are equipped with hydraulic transmission. Thus, the share of diesel-hydraulic locomotives in the total number of all diesel locomotives amounts presently to 17%. The comparison of these two percentages proves clearly that the diesel-hydraulic locomotives, the development of which started virtually only after World War II, succeeded in making their way quickly and increasingly. Already now, out of six diesel locomotives one is a diesel-hydraulic one!

The manufacturing program of KM includes diesel-hydraulic locomotives of all classes of output. But above all, KM has been specializing in the construction of high-powered diesel-hydraulic locomotives. On the basis of the experience gained with the construction of the first six diesel-hydraulic locomotives of more than 2,000 H. P.,—the type V200 of the German Federal Railway,—the KM standard type series of four and six axle diesel-hydraulic bogie locomotives has been developed.

The locomotives of this KM standard type series, either already built or still under construction by KM themselves or to KM drawings or licences are detailed in the following table:

Locomotives of more than 2,000 H. P. of Krauss-Maffei standard type built so far or still under construction.

Report about the Demonstration runs with one of the 4000 HP Diesel Locomotives Type ML 4000 C'C' Made by Krauss-Maffei for the US-Railroads on the Semmering Line of the Austrian Federal Railways in July 1961

REASON AND PURPOSE OF THE DEMONSTRATION RUNS

Two US-Railroad Companies placed an order for 6 Diesel hydraulic locomotives type ML 4000 C'C' with Krauss-Maffei. At the time being this six axle locomotive type with its horsepower of 4000 HP (UIC) is the most powerful Diesel locomotive in the world. Besides that it is the first Diesel hydraulic locomotive with hydro-dynamic brakes. The locomotives ordered will be shipped within short period and shall be put into operation in the Western part of the USA—especially on the difficult mountain lines—within the later part of this year.

After the first locomotive of this type was completed it was put to a detailed dynamometer test run under the direction of the "Versuchsamt fur Brennstofftechnik der Deuts Bundesbahn" (Experimental Test Department for Internal Combustion Engines of the German Federal Railways) in order to find out its efficiency within the total speed range and to check functioning of all component parts. Moreover it was wanted to test a locomotive of this type—before shipping it to the USA—here in Europe under similar conditions of operation as they are existing on the mountain lines in the USA. Already in 1957 Krauss-Maffei demonstrated to the interested international experts the first 6 axle Diesel hydraulic locomotive type with a 2200 horse-power rating on the Semmering line of the Austrian Federal Railway, one of the most difficult mountain lines in Europe. In 1958 there followed the test and demonstration of the first 6 axle Diesel hydraulic locomotive with a 3000 HP rating on the same line. Therefore it is easy to understand that this tradition was followed and that the 4000 HP locomotive type which reprepresents a further development of the two preceding types was also tested on the Semmering line in heavy mountain operation. Thanks to the friendly and helpful cooperation of the Austrian Federal Railway the encountered difficulties could be overcome. The main difficulties were that these locomotives had been built as to American specifications and consequently did not correspond to the European conditions neither with respect to the profile nor to permissible load. By provisionally taking off some parts like hand rails, foot steps etc. the profile restrictions could be overcome. By limiting the fuel supply and the quantity of cooling water the permissible axle load could be reduced to 25.4 tons that means so far that the Austrian Federal Railway could give their approval to the operation of the locomotive on the Semmering line for the traction of regularly scheduled freight trains.

ROUTING

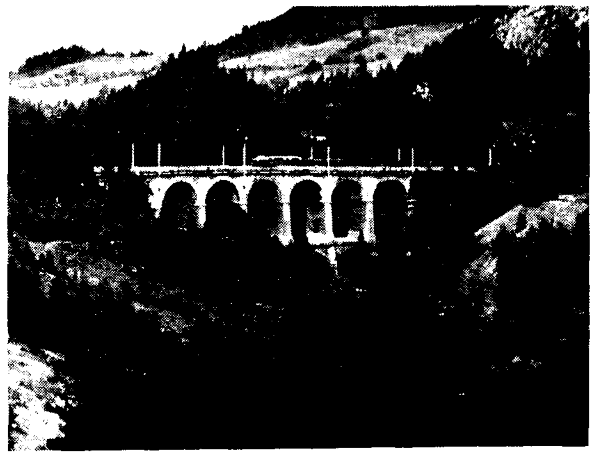
Since the locomotive ML 4000—as to the American custom—is equipped with one driver's cab only the

(Continued from page 18)

Country of operation	Type	Output	Number of axles	Quantity
Germany	V 200	2200	4	86
England	V 200 (D. 800)	2200	4	71
Germany	V 200 (increased power)	2700	4	20
Yugoslavia	ML 2200	2200	6	3
England	ML 2700	2700	6	74
Turkey	ML 2700	2700	6	3
Germany	ML 3000	3000	6	1
U. S. A.	ML 4000	4000	6	6
			total :	264

As against the 264 locomotives of the KM standard type series of 2,200 to 4,000 H. P. listed in this table, there exist altogether 5 diesel-hydraulic locomotives powered with more than 2,000 H. P. which so far have been or are being built by other German or non-German locomotive manufacturers to designs of their own. Thus, the share of KM standard type locomotives in the total number of all diesel-hydraulic locomotives of the same class of output in the whole world is exceeding 98%.

This number is a clear proof of KM's leadership in the development and the construction of diesel-hydraulic bogie locomotives of large output.



demonstration runs could not be restricted to the proper gradient between Gloggnitz and Murzzuschlag because there was no turn-table available at Gloggnitz. Therefore the demonstration runs must be extended to Wiener Neustadt. The line Wiener Neustadt (freight depot)—Gloggnitz—Semmering—Murzzuschlag has a total length of 41.6 miles. From Wiener Neustadt to Semmering the line leads along the difficult northern gradient with many viaducts, tunnels and curves with the smallest radius of 620 ft. The difference in height to overcome between Wiener Neustadt (altitude 832 ft. above sea-level) and Semmering (altitude 2930 ft. above sea-level) is 2050 ft. The largest inclination of the northern gradient amounts to 2.52%. The gradient is given without curve compensation. Including the resistance in curves the largest essential resistance in the line of the northern gradient is calculated by the Austrian Federal Railway with 56 lbs./t. for the calculation of the schedule.

The southern gradient that is the line Murzzuschlag-Semmering, has less difficult operating conditions. The difference in height between these two stations—Murzzuschlag is situated 2220 ft. above sea-level—is about 710 ft. The largest inclination of the southern gradient is 2.39%, the relative maximum line resistance is 52 lbs./t.

EXECUTION OF THE DEMONSTRATION RUNS

The demonstration runs were performed from Monday, 3rd up to Friday 7th July, 1961. Regularly scheduled freight trains were hauled. With respect to the maximum permissible load at the drawbars of the European cars the maximum permissible load hauled for all trains is 964 tons on the northern gradient and 1029 tons on the southern gradient. In order to demonstrate the efficiency of the ML 4000 in an impressive manner the Austrian Federal Railway were asked to load the freight trains to be hauled corresponding to the above mentioned values, which was successfully done.

The Semmering line has been electrified for about three years. With the former steam traction there were hauled fully loaded freight trains by means of three steam locomotives. With the present electric traction they are hauled with two straight electric locomotives. For comparison with the efficiency of the ML 4000 the permissible loads hauled by the formerly used locomotives and by the straight electric locomotives now used for the freight trains are specified in the below mentioned table.

MAXIMUM LOADS HAULED FOR FREIGHT TRAIN TRACTION ON THE SEMMERING LINE AS FIXED BY THE AUSTRIAN FEDERAL RAILWAY WHEN OPERATING

(a) Steam locomotives

type of locomotive	axle arrangement	adhesion weight (t)	indicated horse-power (PSi)	permissible loads hauled (freight train) southern gradient (t)	permissible loads hauled (freight train) northern gradient (t)
52	I'E	82.7	1620	396	331
42	I'E	94.0	1800	495	441
95	I'EI	79.2	1037	364	331

(b) Straight electric locomotives

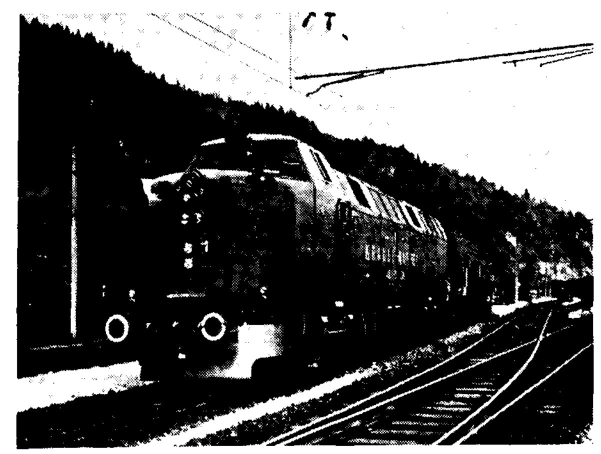
type of locomotive	axle arrangement	adhesion weight (t)	hourly horse power at the shaft of the traction motors	permissible loads hauled (freight train) southern gradient (t)	permissible loads hauled (freight train) northern gradient (t)
10.41	BoBo	92.5	3200	395	374
11.10	CoCo	119	5400	694	638

Before the execution of the runs it was maintained that one ML 4000 is in the position to haul fully loaded trains on the southern gradient as well as on

the northern gradient i.e. that the permissible loads hauled for this type of Diesel locomotives are not restricted by its efficiency but only by the load limit at the drawbars of the hauled rolling stock.

This assumption was proved right during the runs as shown a comparison of the values mentioned in the above table with the results of the demonstration explained in the following paragraph.

The demonstration runs were daily performed within the same schedule. In the morning a regularly scheduled freight train was hauled from Wiener Neustadt uphill the northern gradient to Semmering and then downhill the southern gradient to Murzzuschlag and in the afternoon a regularly scheduled freight train from Murzzuschlag in the opposite direction back to Wiener Neustadt. Because of the axle load of 25.4 tons the Austrian Federal Railway limited the maximum speed to 28 MPH for the entire line and for all runs. During all runs a dynamometer car followed the locomotive as first car.



By means of recording instruments these were measured in the usual way speed, tractive effort at the drawbar and during the first runs in order to control the former measuring runs the temperatures in the oil, water and air circuits of the machine set. Moreover there was controlled effectiveness of a new-developed anti-slip device used in this locomotive by means of a recording instrument. Thus it was possible to properly note the results of the runs and to enable the guests during the runs to convince themselves of the efficiency of the locomotive. By this way it was also possible to accommodate the large number of guests in the train as the space within the one driver's cab of the locomotive was naturally insufficient.

Unfortunately we had to desist from a direct measuring of the braking power produced by the hydro-dynamic brake of the locomotive since no suitable equipment was available. The examination of the hydro-dynamic brake had to be kept restricted to the observation of its effectiveness on the different inclinations of the line.

RESULTS OF THE DEMONSTRATION RUNS

The weight of the trains hauled uphill every day from Wiener Neustadt to Murzzuschlag along the northern gradient was between the minimum value of 928 tons with 86 axles and the maximum value of 955 tons with 88 axles. On the line from Murzzuschlag to Wiener Neustadt i.e. on the return uphill along the southern gradient these values were between 902 tons with 96 axles and 1068 tons with 106 axles. The values mentioned refer exclusively to the regularly scheduled freight trains hauled and consequently do not include the weight and number of axles of the locomotive.

For judging the measuring values of the tractive effort and speed and their comparison with the computed values it must generally be stated that the measuring of the tractive effort depending on the speed only shows absolutely correct values if a proper continuous state of running is obtained on a line with a constant inclination and without any curves. With regularly scheduled runs—especially on such a difficult line—it is only roughly possible on a few parts of the line.

The evaluation of the recording tapes showed that with runs uphill the northern gradient on three parts of the line and uphill the southern gradient on two parts of the line such a continuous state of running could be approximately obtained with sufficient accuracy during all the runs performed on these five days. In order to eliminate eventual discrepancies of measurings and slight differences in the measuring values during the individual runs caused by weather conditions there was formed a tractive effort and speed average value for each of these five parts of the line out of the measuring values of all runs performed during the time from the 3rd to 7th July, 1961.

This calculation of the average values eliminating the sources of errors is possible as, caused by the approximately similar weights of the trains and the performance of the locomotive which was the same during the five days on the same parts of the line, an approximately similar continuous state of running and therefore also an approximately similar tractive effort could be obtained. The following table shows the average values concerning the tractive effort and the speed resulting from five runs measured on the five parts of the line at approximately continuous state of running. In this table these measured values are compared with the rated values of the tracjive effort calculated at the corresponding speeds for the different inclinations. With this calculation the tractive efforts at the draw-bars on a plane and straight line were taken out of the published diagram precalculated for full load (adjusted maximum engine horsepower = 3800 HP). Those were reduced by the gradient resistance of the locomotive on the different inclinations with a locomotive weight of 152 tons with which the locomotive was running on the Semmering line. The further necessary reduction by the curve resistance of the locomotive was neglected and consequently a certain safety factcr was introduced in the comparing calculation.

Comparison of the measured tractive efforts with the computed tractive efforts of the three parts of inclination on the northern gradient and the two parts of inclination on the southern gradient.

inclination in %	2.13	2.23	2.39	2.5	2.5
measured speed in MPH (average value out of five runs	18.5	17.6	16.2	15.8	16.25
measured tractive effort in tons (average value out of five runs)	22.40	24.03	25.71	25.82	25.80
computed tractive effort in tons (rated value)	22.40	23.71	25.50	25.55	25.00
surplus of the measured tractive effort compared with the rated value in %	0.0	1.2	0.8	1.3	3.5

The comparison of the tractive efforts measured on the individual parts of inclination at continuous state of running with the computed rated values shows that there exists an equality on one part of inclination while on all the other parts of inclination the measured tractive efforts even slightly exceed the calculated values.

The computed efficiency of the locomotive and therefore its operation on difficult mountain lines is consequently proved and one of the main purposes of the Semmering runs is fulfilled in an impressive way.

During the runs on the Semmering it was only possible to measure the range of the low speeds at full load. In this respect we have to mention that the test on the Semmering line was performed just because of this purpose as the locomotives will be operated on the difficult mountain lines of the USA under largely similar conditions concerning the inclination and curves of the line as well as the load hauled per locomotive.

Further impressive proofs of the efficiency of the locomotives are given in consideration of the speeds reached with the loads hauled and the performed starts with these loads on the steep gradients.

The average value of the load hauled during the five runs performed on the northern gradient uphill amounted to 942 tons with 78 axles. The following speeds of continuous state of running were obtained on an average during all five runs on the three parts of inclination.

2.23% with the smallest radius in curves of 620 ft.—9.25° degree curve = 18.4 MPH

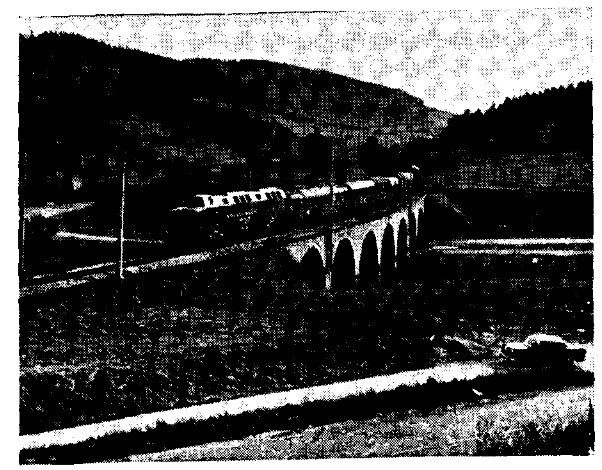
2.5% with the smallest radius in curves of 930 ft—6.18° degree curve = 16.2 MPH

2.52% with the smallest radius in curves of 930 ft—6.18° degree curve = 16.8 MPH

The average of load hauled during the five runs on southern gradient uphill amounted to 981 tons with 90 axles. On the two parts of inclination of the southern gradient the following medium speeds at continuous state of running were obtained :

2.13% with the smallest radius in curves of 1245 ft—4.25° degree curve = 19.4 MPH

2.39% with the smallest radius in curves of 930 ft—6.18° degree curve = 16.8 MPH



For the demonstration runs on the Semmering line a SV-diagram for a load hauled of 961 tons was computed. A comparison of the values obtained with the rated values of this diagram shows that with the slighter really hauled medium load of 940 tons on the northern gradient the actual speeds were in all points above the computed speeds. With the slightly higher medium load of 981 tons hauled on the southern gradient these were obtained, however, just the speeds calculated for a load of 961 tons.

This comparison, too, shows the good conformity whereby, however, one must consider that a SV-diagram cannot be directly consulted to prove the efficiency since the conformity of the actual running resistance values of the locomotives with the values calculated according to the usual formula is a condition for the consideration of a SV-diagram. Although the always existing difference in the running resistance of individual trains could be equalized to a certain extent by the calculation of the average value an uncertainty factor naturally continues to exist. First of all it must be considered that with the calculation the considerable curve resistance of the trains as it doubtlessly exists on the Semmering line was not taken into consideration. By this fact it might be explained why a higher speed was obtained on the 2.52% inclination of the northern gradient than on the 2.5% part of inclination.

When summarizing conclusion is drawn from the results that in an altitude up to approximately 3271 ft the locomotive can surely haul a load of 961 tons on lines of 2.5% inclination with not compensated curves having curve radii down to 622 ft. at a speed of (continuous state of running) 16.3 to 16.8 MPH.

In order to demostrate the starting efficiency especially difficult starts not as scheduled were performed namely on the northern gradient uphill at kilometer stone 84 and on the southern gradient uphill at kilometer stone 112. Before starting on the northern gradient locomotive and train were at standstill on an inclination of 2.52% and this in a S-curve with curve radii of 6.18° and 4.85°. The train hauled had a weight of 955 tons with 88 axles. In throttle step 10—(full throttle step 15)—locomotive and train started moving. The measured starting tractive effort at the drawbar was about 38.5 tons. The maximum tractive effort measured during this start was 40 tons at about 2.48 MPH. In throttle step 15 (full load) a tractive effort of 35.2 tons at about 9.95 MPH was obtained, which again exactly corresponds to the rated value of the tractive effort on such an inclination. Thereupon the locomotive accelerated the train to the speeds usual on those parts of the line. However, because of the shortness of inclination available, no continuous state of running value could be obtained. The measured resistance of the train of 38.5 tons is especially high. Quite obviously the speed of this train was especially low which was proved by the fact that speeds obtained by this train on the entire route were the lowest ones compared with all the other runs performed. Before starting on the southern gradient the locomotive and train were at standstill on an inclination of 2.39% and this on a straight line which was interrupted only by a short curve with a radius of 2°.

The weight of the train was the maximum load hauled during all the days and amounted to 1068 tons with 106 axles. In throttle step 9 locomotive and train started moving and the measured tractive effort at the drawbar of the locomotive was about 32 tons. In throttle step 15 (full load) the tractive effort rose to the usual rated value. At the end of this part of inclination the speed to which the locomotive accelerated the train on this inclination was 15.4 MPH. In consequence of a transition to a slighter inclination the speed rose again rapidly.

Especially remarkable for the two starts as above described is the fact that they were performed without using sand and that with these starts no slipping occurred as was correctly indicated by the wheel-slip indicating instrument.

As formerly mentioned, contrary to the measuring runs performed by the Experimental Test Department for Internal combustion Engines of the German Federal Railway on the German lines during the spring season it was not possible, due to the lacking of suitable instrumentation, to measure the brake efforts developed on runs downhill. The practical effectiveness of the brake, however, could be tested in a much more impressive way on the gradients of the Semmering. The runs downhill the northern gradient were of special importance on the one hand because of the greater inclinations of the northern gradient and on the other hand because the weights of trains could be increased correspondingly to the conditions, of the Austrian Federal railway during runs uphill the southern gradient and downhill the northern gradient. During all the runs downhill the trains were braked almost in all instances with hydro-dynamic brakes except in cases where scheduled and unscheduled brakings on slowdown orders and exceptionally low speeds were necessary. In this connection the run with a load hauled of 1068 tons was particularly remarkable.

Summarizing it can be stated that the hydro-dynamic brake of the locomotive was able to keep all the weights of the train up to 1068 tons in a continuous state of running on all parts of inclines at speeds between 18.6 and 24.8 MPH, permissible for those parts. On the greatest parts of incline with inclines of about 2.5% full braking efficiency, i.e. brake step 8, was necessary while on slighter inclines partial braking steps were sufficient.

The measuring of temperature performed during the runs of the first day in order to control the former measurings show that all temperatures in the water, air, and oil circuits remained in permissible limits. The especially important measuring of the transmission oil temperature at the hottest point of the circuit, namely at the output of transmission, showed a maximum oil temperature of 194°F with runs uphill and when braking on runs downhill a temperature of 224.6°F. These temperatures, too, are far below the permissible limit. From experience we know that the maximum temperatures are reached after a short full load run and remain constant and therefore these runs can be regarded as proof for continuous operation. It is worth while calling your attention to the fact that the outside temperatures on the days of tests reached 89.6° F in the shade.

The fuel consumption for the line Wiener Neustadt—Semmering-Murzzuschlag and return i.e. for a daily route of a total of 83 miles was estimated, including a small reserve, at about 400 gallons. For all the five runs performed including the necessary shunting operations 316 gallons were consumed approximately. For judging the fuel consumption it must be noted that on the run from Wiener Neustadt to Semmering a difference in height of 2050 ft. and on the return from Murzzuschlag to Semmering a difference in height of 710 ft. i.e. a total difference in height of 2760 ft. on runs uphill had to be overcome. Generally valid conclusions of the consumption on the line of the locomotive cannot be drawn from the consumption measured, it corresponds, however, very well to the consumptions measured during the demonstration runs with the 2200 HP and 3000 HP locomotives on the Semmering in the years of 1957 and 1958.

SUMMARY AND FINAL ANALYSIS

Preceding overseas delivery of the six US-Railroad locomotives built by Krauss-Maffei with Maybach engines and Voith transmissions one of these 4000 HP locomotives was demonstrated on the Semmering line in Austria, one of the most difficult mountain lines of Europe. The demonstration was performed from 3rd to 7th July, 1961 in heavy freight train service. In a dynamometer car of the Austrian Federal Railway the performance values were measured and registered. The data showed that in all cases the computed tractive efforts were obtained and partially even exceeded. During the runs on inclines this locomotive which was the first type equipped with hydro-dynamic brakes met all expectations. The most important results of the demonstration runs are given in this report.

The locomotive endured the first load test in practical operation under most difficult conditions without the slightest difficulties.

The performance values obtained by this locomotive on the Semmering line exceed all performance values of Diesel locomotives hitherto known and herewith confirmed that this type of Diesel locomotive can be regarded as the most powerful Diesel locomotive of the world built up today. A great number of interested experts of home and abroad had the opportunity to convince themselves personally and to get an impression of the excellent running characteristics and the remarkably low noise level in the driver's cab of the locomotive.

Standardized Transmission for Mixed-Duty Locomotives

The New Rolls-Royce Type S System Described

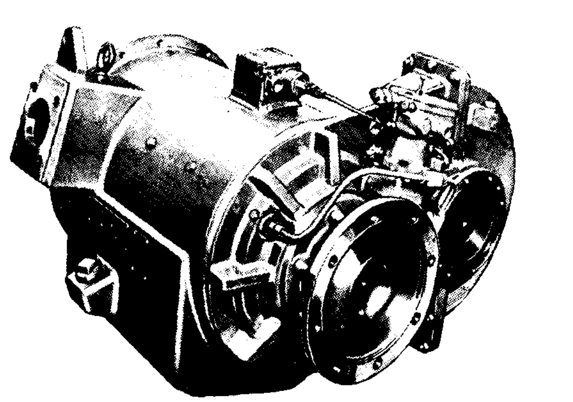
PROPOSALS for the use in locomotives of two or more engines, with torque converters and a differential gearbox, were set out in a paper presented in March, 1960, to a meeting of the Automobile Division of the Institution of Mechanical Engineers. The authors were Lt.-Col. L. F. R. Fell, D.S.O., O.B.E., M.I.Mech.E., and Mr. K. D. S. Tyler, A.M.I.Mech.E., A.M.I.Loco.E., both of Rolls-Royce, Ltd.

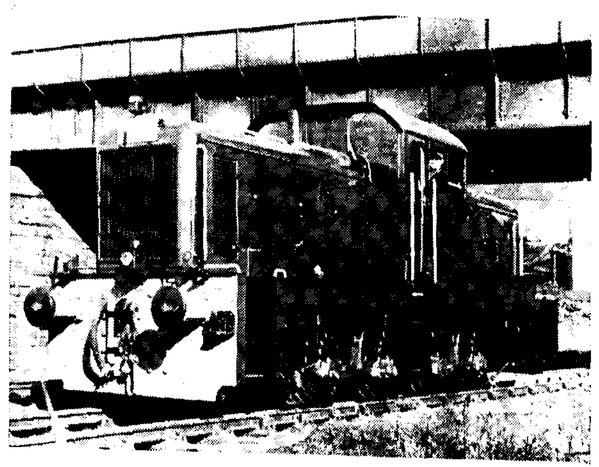
Rolls-Royce now offer standardized diesel, hydraulic equipment for mixed-duty locomotives in the 400 to 800-h.p. range. The first practical application of the R-R Type S transmission, as the new system is known, is to be seen in the 600-h.p. 0–8–0 Taurus locomotive built by the Yorkshire Engine Co., Ltd., of Sheffield.

In principle the Type S system, compared with more conventional layouts, can give either (1) a higher initial tractive effort and the same maximum continuous speed, or (2) a higher top speed and the same initial tractive effort. Taurus is an example of the first and more usual case. Taking the criterion of maximum continuous speed, then the effect of the S transmission is to extend the continuous working range downwards to a very low speed, as well as to improve the operating characteristics, but other advantages accrue.

COMPOUNDING GEARBOX

The layout comprises: (a) two Rolls-Royce diesel





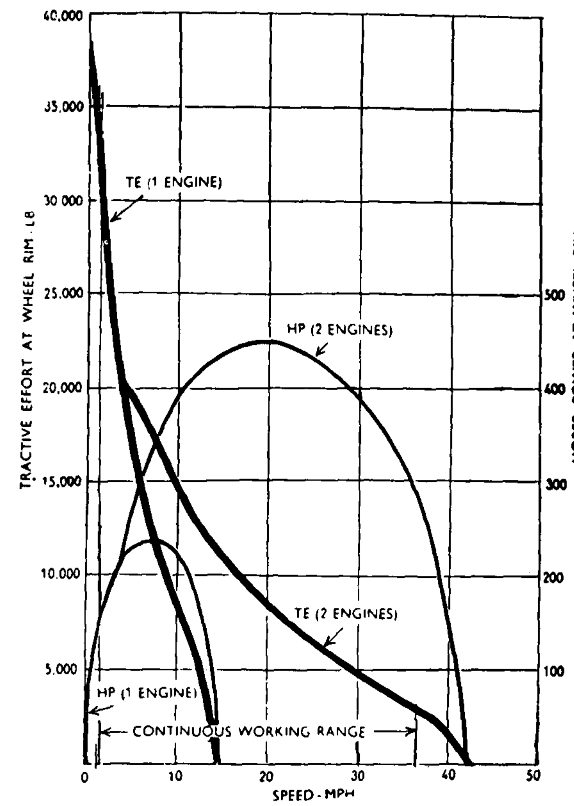
Taurus diesel-hydraulic 58-ton locomotive built by Yorkshire Engine Company, Ltd., in which is used the Rolls-Royce Type S transmission

engines selected from a rationalized range, with matched Rolls-Royce torque converters (manufactured under licence from Twin Disc Clutch Company, U.S.A.); (b) a differential gearbox, to which the drive from both engines is fed; and (c) a final drive, reduction and reversing gearbox.

Matters are so arranged that maximum starting effort is available from one engine, the other being brought in to give higher rail speeds. It is a leading feature of the transmission that with only one engine driving, the locomotive can give full tractive effort for continuous low-speed shunting duties. As will be explained, the drive from the second engine is engaged without a break in torque and with no torque surge. There is no gear changing to be done by the driver.

Key item in the system is the compounding gearbox containing the differential, the action of which is explained by reference to an accompanying diagrammatic sketch. The differential has two bevel wheels, and three pinions mounted on a spider, from which

←Rolls-Royce CGD 710 differential compounding gearbox



*Typical performance curves (*not Taurus*) based on two C8S engines, 297 b.h.p. net each at 1800 r.p.m., with a final drive ratio of 8.4 : 1 and a wheel diameter of 3 ft. 9 in.*

the drive to the output cardan shaft is taken. Each engine drives one bevel wheel.

No. 1 engine drives directly, through its torque converter, on to its bevel wheel, whereas the drive from No. 2 engine and torque converter is fed into its bevel wheel through speed-increasing spur gears. In the case of Taurus, the spur gears have a ratio of 1.88 to 1.

When No. 1 engine only is driving, a sprag-type one-way clutch holds stationary the second bevel wheel, and the differential in this condition gives a torque multiplication of 2 : 1.

The stall torque ratio of a converter is 5 : 1, and as the speed reduction in the final drive is in the region of 10 : 1 the total torque multiplication is nearly 100 : 1 between No. 1 engine and the driven axles. This is ideal for giving maximum tractive effort at a steadily maintained low rail speed. When both engines are driving, the differential automatically ensures a balance of torque between both engines.

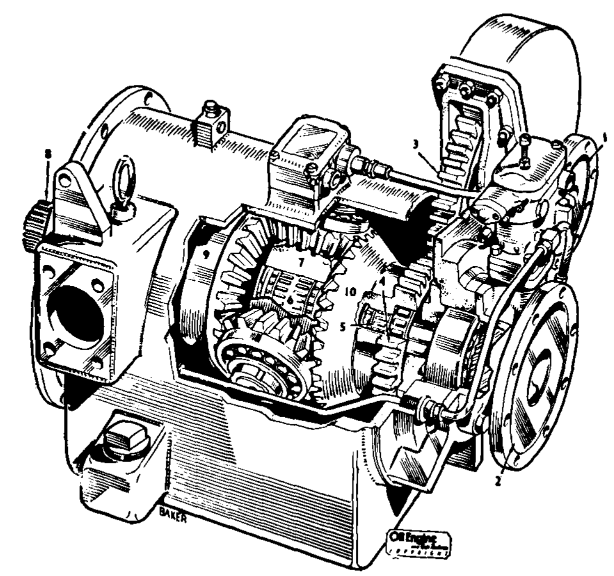
A second sprag clutch is incorporated between the differential spider and the output shaft, the function of which is to act as a free wheel to prevent the differential from being overspeeded during overrun.

Both sprag clutches are properly known as Borg-Warner full-phasing one-way clutches. The differential free wheel has two rows of sprags in tandem, so as to give the required load-bearing capacity in the dimensions available. Each row is carried in two concentric cages, so that all sprags are bound to be in phase, that is, they will take up the load together and will all carry their full share of the load.

The other sprag clutch, controlling No. 2 engine bevel wheel, has only one row of sprags but is of larger diameter.

DRIVING TECHNIQUE

In the practical handling of a locomotive with this transmission it will be seen that No. 2 engine is introduced for trip working, whereas for continuous shunting at low speeds No. 1 engine only will be used



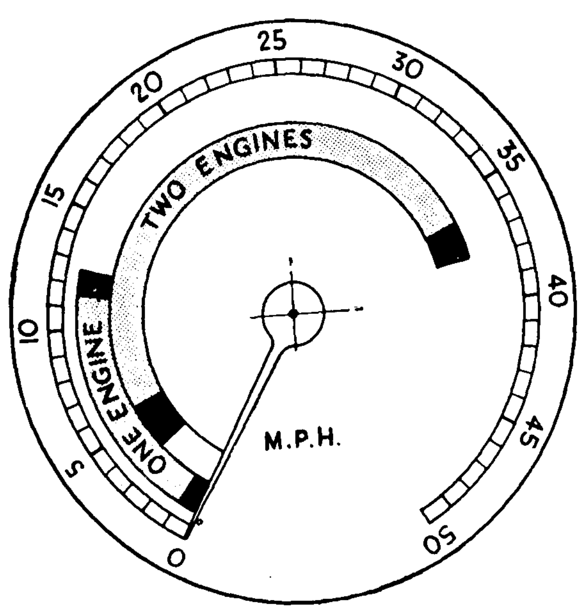
The Power Distribuiion Centre

Arrangement of gears and sprag clutches in the differential compounding gearbox:
1, No. 2 engine input mating flange; 2, output shaft mating flange; 3 and 4, No. 2 engine input speed increasing spur gears; 5, single-row Borg-Warner one-way clutch; 6, double-row Borg-Warner one-way clutch; 7, differential spider; 8, No. 1 engine input mating shaft; 9, No. 1 engine bevel wheel; 10, No. 2 engine bevel wheel

The driver will normally be aware what his duties for the day are to be, so he is in a position to decide at what point to start up No. 2 engine if it is to be required. Control is now dealt with more fully.

To assist the loco. driver achieve the optimum performance from the proper handling of his charge the speedometer is marked in coloured bands, which show the continuous and intermittent performance ranges for both one and two engines. Four driving controls are provided, namely, engine selector, regulator, reverse lever, and brake. Both regulator and reversing lever operate through air-pressure systems.

Initial movement of the engine regulator, that is from its closed to its idling position, engages No. 1 engine-torque converter clutch only. Further movement of the regulator progressively increases power from No. 1 engine, which will give a useful performance up to about 12 m.p.h. After starting up, No. 2 engine is brought in by moving the selector lever, which controls the No. 2 clutch and the No. 2 engine regulator. The No. 2 engine now responds to the same regulator, therefore progressively increasing the speed of the second bevel wheel and hence reducing the effective ratio of the differential towards unity as vehicle speed increases.



Marking of the driver's speedometer dial, which in practice is done in colour. The tint indicates where the transmission is continuously rated when working on one or both engines, whereas in the white and black bands power may be sustained for restricted periods.

If the regulator is now returned to the idling position, with both engines running, the engines are reduced to idling speed, as might occur during a temporary stop when trip working. If, however, the regulator is further moved to its closed position the second engine clutch is disengaged and the engine will not now respond to the regulator unless re-selected. Yorkshire Engine Company's Taurus locomotive has the added advantage of a second clutch on the No. 2 torque converter, the purpose of which is to maintain high efficiency by locking out the converter and engaging direct drive at about 29 m.p.h.

Reverse gear is operated by a pair of Westinghouse diaphragm cylinders and the reversing lever is interlocked with the regulator, and with a standstill detector, so that reverse cannot be engaged unless the regulator is closed and the locomotive stationary.

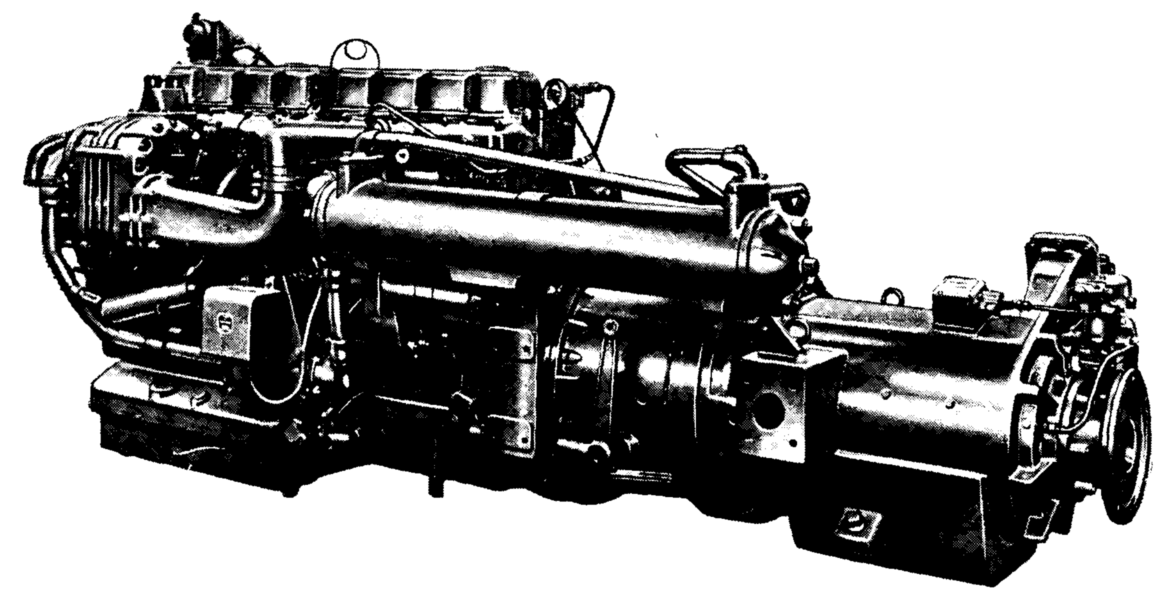
Positive lubrication of the compounding differential gearbox is ensured by a gear-type oil pump driven from No. 1 input shaft, with the exception that No. 2 input shaft bearings are splash lubricated. The differential gears, all hardened and ground, are Zerol spiral bevels.

LOW FUEL CONSUMPTION

Any suitable pair of Rolls-Royce engines can be designed into an S transmission layout, to give the required power output and operating characteristics. Spur gears in the differential gearcase may be in any reasonable ratio between 1 : 1 and 1.88 : 1. Final-drive gearcases would be substantially the same within a range of ratios from 5 : 1 to 9.875 : 1. Other locomotive designs might have different control systems.

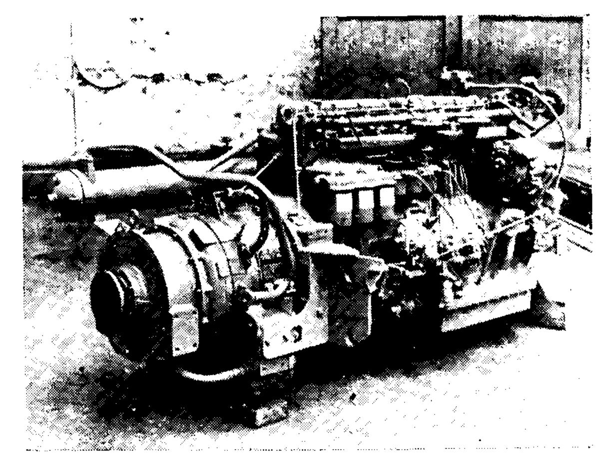
Using only one engine to give the maximum tractive effort means that the engine is running at a speed at which its specific fuel consumption is low while the efficiency of its torque converter is high. Weight of the power equipment is about 5 tons per power pack, or 16—18 lb. per horse power. The use of two engines permits the choice of a central cab layout with consequent good visibility, but in principle there is no reason why the engines should not be placed side-by-side. One of the factors governing visibility is bonnet height which, in turn, may be influenced more by size and position of radiators, especially when designed for high ambient temperatures, than by type and position of engines.

The capital cost of two engines and transmissions is generally lower than the corresponding single-engined



Rolls-Royce C8S engine in the No. 1 position, coupled to Twin Disc CF 11,500 Ms 390 torque converter and differential compounding gearbox

No. 2 engine, in this case with a DF converter as used in the Taurus loco. In both illustrations the converter fluid heat exchanger is clearly seen



power group. Smaller engines may be changed with ease by the operator in his motive-power running shed, and there are advantages in spares holdings and maintenance through having only one make and type of engine in a railway system.

As has been seen, full tractive effort with the S transmission comes from one engine only which, on shunting duties particularly, will lead to reduced wear-and-tear costs, favourable fuel consumption and flexibility in locomotive operation.

[*Courtesy : The Oil Engine and Gas Turbine.*]

MANUFACTURE OF DIESEL ENGINES

The Government have decided to undertake the manufacture of diesel locomotives at the locomotive components works at Varanasi, in Uttar Pradesh.

Announcing this in the Lok Sabha to-day, the Deputy Minister of Railways, Mr. Shah Nawaz Khan, said that Varanasi was chosen because the existing factory there could be remodelled and production could be undertaken with the least possible delay. Moreover sufficient land, building and water supply were available at Varanasi. The question which foreign firm would collaborate with the railways for the manufacture of the locomotives was still to be decided.

UNUSUAL VENTILATING SYSTEM FOR DIESEL-ELECTRIC LOCOMOTIVES

By John C. Aydelott
Locomotive and Car Equipment Department
General Electric Company, Erie, Pa., USA

ALTHOUGH clean, dry air has always been regarded as ideal for the ventilation of locomotive traction equipment, never until today has it become an actuality on diesel-electric locomotives. The radically new ventilating system of General Electric's 2500-hp U25B locomotive for the first time provides an ample supply of clean, dry air.

Making this practicable was a large order indeed. One original objective was to keep dirt, snow and water out of the equipment and out of the locomotives itself. Pressurization of the locomotive interior became another objective, but this in itself did not go far enough. Once in the cab, this air would be contaminated by exhaust fumes and oil vapor. Attempts were made to find room for the addition of air ducts in the already crowded conventional locomotive designs. There was just no place for the large ducts required to handle such quantities of air.

Almost as a joke G-E engineers said, " We will have to design the air system first and then build the locomotive around it ". Unconventional as this seemed, it proved to be the way to make a really simple locomotive as well as to provide clean, dry air for all uses on the locomotive. The main platform sills became the sides of the air duct. They were made unusually deep to obtain a large duct and at the same time provide the required platform strength with minimum weight. This duct was sealed to prevent the entrance of any oil seepage, not a single pipe or wire runs into or out of it at any point.

DESIGN PROBLEMS

A basic requirement was that the air cleaning means should require no maintenance or inspection. If any attention whatever was required it should be at intervals of not less than a year. Many cleaner-blower combinations were investigated. Space arrangement problems were never satisfactorily solved, but the biggest reason for not using a cleaner-blower arrangement was that the dirt cleaning efficiency did not measure up to the standard that had been set.

Investigation turned to static dirt separators working on the centrifugal principle. The one selected uses the principle originally disclosed in the F.B. Schneider Swiss patents 176351, 176352 and 176353 now expired. There are no moving parts in this type of cleaner. The cleaning element is a tube which has no obstruction in the center where a true vortex forms as the air whirls through the tube. See Fig. 1. Maximum cleaning efficiency depends upon the proportions of the tube as stated in the Schneider patent.

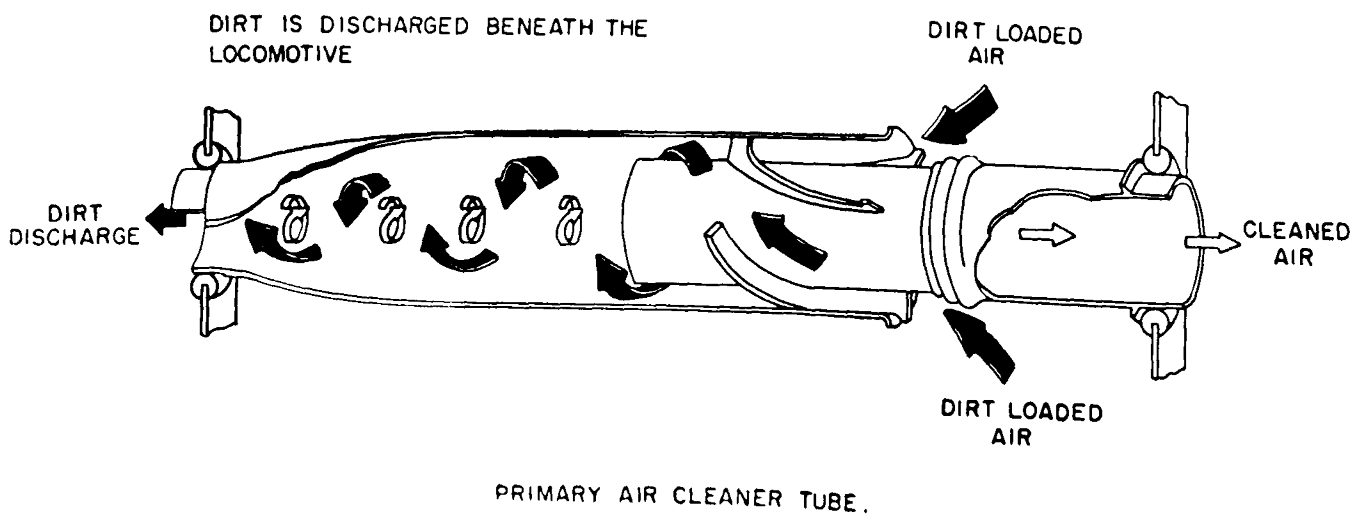


Fig. 1. Cross section of primary air cleaner tube, showing directions of air flow

In order to obtain the required capacity 1470 tubes are used in the cleaner. Air is brought to the cleaner under pressure. This permits the dirt which is removed from the air to be discharged continuously under the locomotive so that the cleaner requires no servicing.

In arriving at the final cleaner design, various size tubes were considered. Certain basic considerations led to the choice of a 2-inch diameter tube. This tends to be more efficient than larger tubes because, for a given pressure drop and air velocity through the tube, centrifugal forces are greater as the center of a vortex is approached. The material finally selected for the tubes was glass-reinforced nylon. This gives an extremely smooth surface, which makes for maximum cleaning efficiency. The material is less subject to abrasion than metal and will have longer life. It is unaffected by any natural conditions, and by detergents or cleaning compounds which may be run through it on the locomotive.

SYSTEM OPERATION

A specially-designed axial-flow blower, gear driven from the diesel engine and mounted above the cleaner, see Fig. 2, produces sufficient pressure to propel the air through the cleaner and provide ventilation of all the blown machines on the locomotive. Equipment and radiator air enter the locomotive together through large openings on both sides of the radiator compartment so that there is a minimum opportunity for this air to pick up engine fumes or oil vapor. The resistance grids for dynamic braking are hung in this combined air stream. Two radiator fans, driven by the same gear box as the equipment blower, force air upward through roof-mounted radiators.

Cleaned air fills the duct between the locomotive platform sills, where it is easily available for all locomotive requirements. See Fig. 3. The four traction motors receive their air through short, straight flexible connections. The main generator is immediately above the central air duct and receives an ample supply of clean, dry air free from oil fumes—a decided contrast to most generators which draw hot, oily air from the cab. The exciter and auxiliary generator also receive air under pressure through short, direct connections from the main air duct. The interior of all these machines is at a higher pressure than the air in the apparatus cab so that leakage is outward, eliminating any tendency for contamination from the engine to enter them. The control compartment is tightly sealed with gaskets around all outside doors and is connected to the main air duct so that the interior always has a positive pressure to prevent the entrance of moisture or dust.

A feature highly favored by many train crews is the ventilation of the operating cab with cleaned air. A heater is arranged to warm this air in cold weather to maintain any desired cab temperature. Crews have expressed surprise that they do not experience the groggy feeling at the end of a run that they have come to expect when operating most diesel-powered loco-

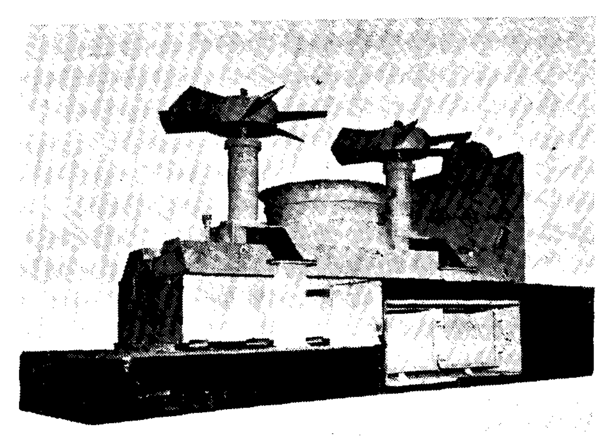


Fig. 2. Gear-driven radiator fans (right and left) and equipment blower (center) are mounted on top of the primary air cleaner. Opening at lower right marks location of two of the four panelbath filters for secondary cleaning of diesel engine combustion air

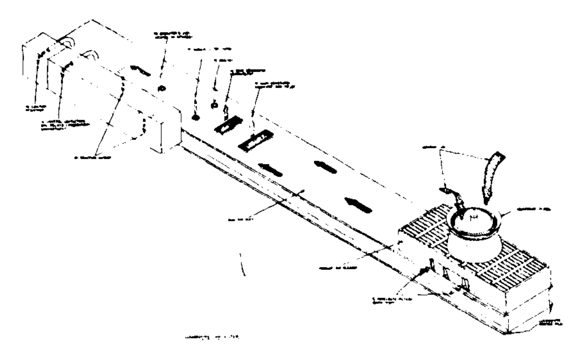


Fig. 3. Diagrammatic sketch of principal features of the locomotive air system

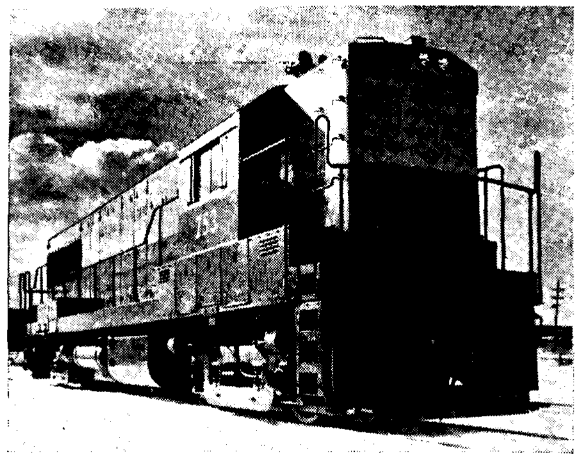


Fig. 4. General Electric U25B 2500-hp diesel-electric locomotive for main line service. Ventilating air intake and radiators are located at the far end of the cab

motives. The fact that air is fed into the cab minimizes drafts from cracks around doors or windows.

The large volume of air discharged from the generator and auxiliary machines pressurizes the engine hood. This prevents the entrance of dirt around the doors or through any other opening in the hood. Customarily diesel engines use an exhauster to create a partial vacuum in the crankcase and purge it of oil vapor. Dirt carried into the engine hood may be drawn into the engine crankcase wherever there is an opening for air to leak in. Here it mixes with the lubricating oil and is a prime cause of wear on engine parts. The fact that, on the U25B, the engine hood is pressurized with cleaned air minimizes the danger of dirt directly entering the crankcase and the lubricating oil.

Air is discharged from the pressurized engine hood through an opening around the turbocharger exhaust stack. This, coupled with the fact that the stack is extended several inches above the locomotive roof, insures that a minimum of exhaust will follow the contour of the cab and there will be no tendency for it to mix with the air entering the locomotive.

Diesel engine combustion air is drawn from the locomotive air system through panelbath filters. It is available under pressure as it enters these secondary cleaners. Part of this pressure reaches through to the turbocharger intake, improving engine operating conditions. Because the primary air cleaner is so efficient, these secondary cleaners can be designed to do a superlative job. At the same time, they accumulate dirt so slowly that they require servicing only at extremely infrequent intervals.

Extensive operating experience under all sorts of conditions has demonstrated that the dream of a locomotive design providing clean, dry air for combustion, for all ventilating uses, and for the comfort of the crew has been realized. At the same time many blowers, blower motors, etc. have been eliminated and maintenance work on the air system reduced practically to the vanishing point.

Electric Locos for Eastern Railway

The Railway Board, it is announced in Calcutta has placed an order with Mitsubishi Electric Manufacturing Company Limited of Tokyo for 28 complete 25 K. V. single phase, 50 cycles electric locomotives and other related equipment and spares.

The locomotives are expected to be utilised to successfully solve the problem of heavy suburban passenger traffic to and from Calcutta on the Eastern Railway between Sealdah and Kalyani.

The total value of the order placed with this firm amounts to nearly three crores of rupees. The Japanese manufacturers have promised early deliveries of these locomotives to suit the programme of the Eastern Railway and the supply will be according to the stipulations of the Railway Board. The delivery of the first locomotive is expected to be made 14½ months after the placement of the order and the last one, 30½ months after the placement of the order.

It may be recalled that in this connection global tenders were invited and tender documents were issued to seven manufacturers of international repute. Tenders were received from two British firms, a firm representing a European group of manufacturers and Mitsubishi Electric Manufacturing Company Limited representing a group of manufacturers in Japan.

Current Collection for Electrical Traction—Pantographs

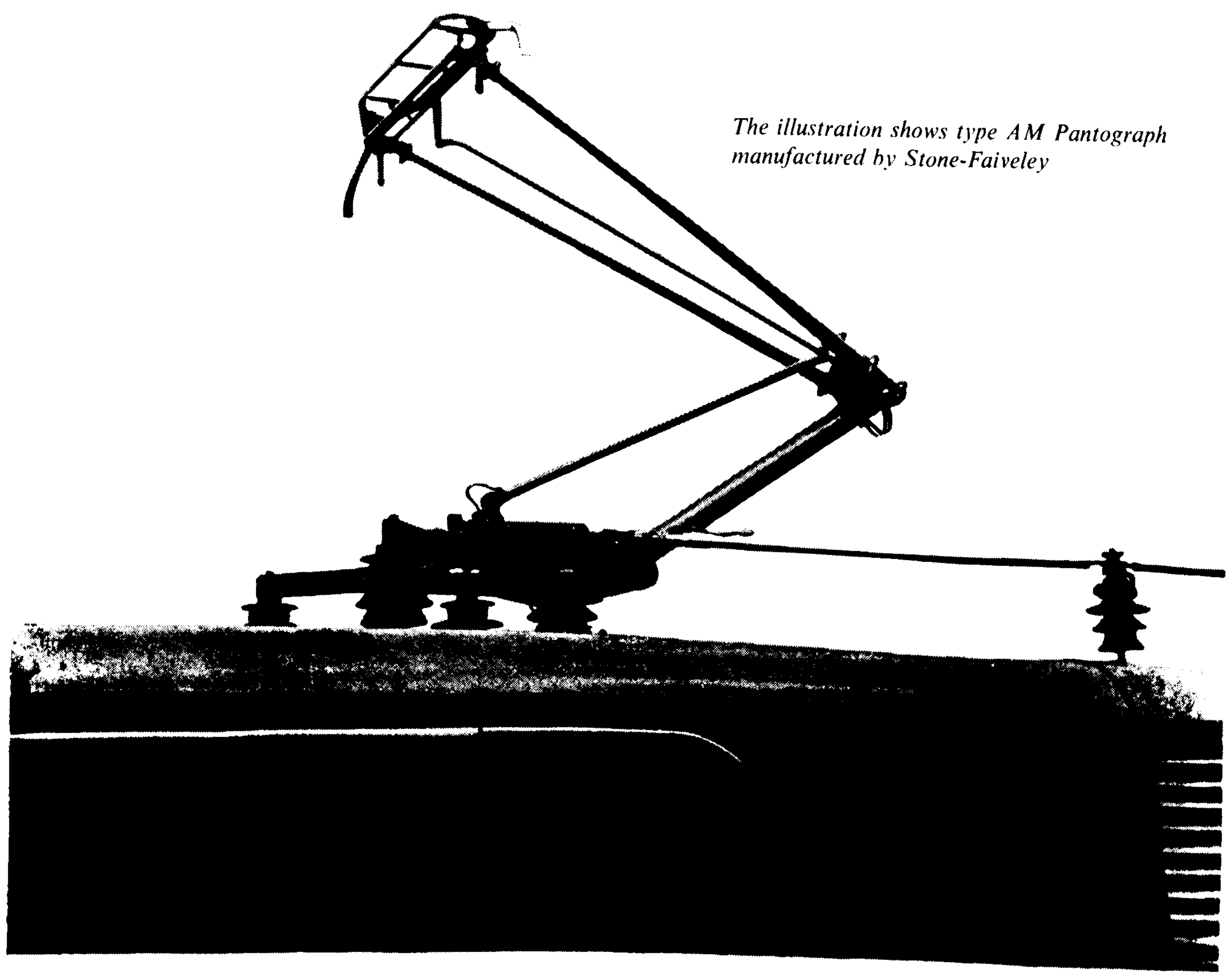
The latest trend in Railway Electrical Engineering is to adopt high voltage A. C. at the industrial periodicity of 50 or 60 cycles per second for overhead traction current collection. This has proved both economical and flexible to suit main and branch line systems for both passenger and freight, for locomotives and multiple-unit stock.

The utilisation of high voltage has permitted the embodiment of light-weight overhead construction which in turn has demanded a current collector mechanism that is particularly sensitive and precise in its performance up to the maximum speed— in some countries this is 100 m. p. h.—in order to give maximum continuity of traction current in such a way as to minimise disturbance to the overhead catenary and structural apparatus.

Such a current collector is the Stone-Faiveley type AM pantograph, now being supplied by J. Stone & Co. (India) Private Ltd. A typical example is illustrated herewith. Orders have been executed for 22 such pantographs for use on locomotives, and most of these are in service on the Indian Government Railways at 25 kv; a further order is pending for 64 pantographs.

On existing systems for 1,500 volts D. C. traction of the Indian Government Railways, orders have been received and completed for 22 pantographs, and a further order has been received for 24 pantographs of the same type (AM) suitable for the higher currents obtained at 1500 volts.

Servicing and eventual complete manufacture of Stone-Faiveley pantographs will be carried out by Messrs. J. Stone & Co. (India) Private Ltd. of Behala Works, Taratalla Road, Calcutta 27, to whom all enquiries should be addressed.



The illustration shows type AM Pantograph manufactured by Stone-Faiveley

LOCOMOTIVE RADIO TELEPHONES

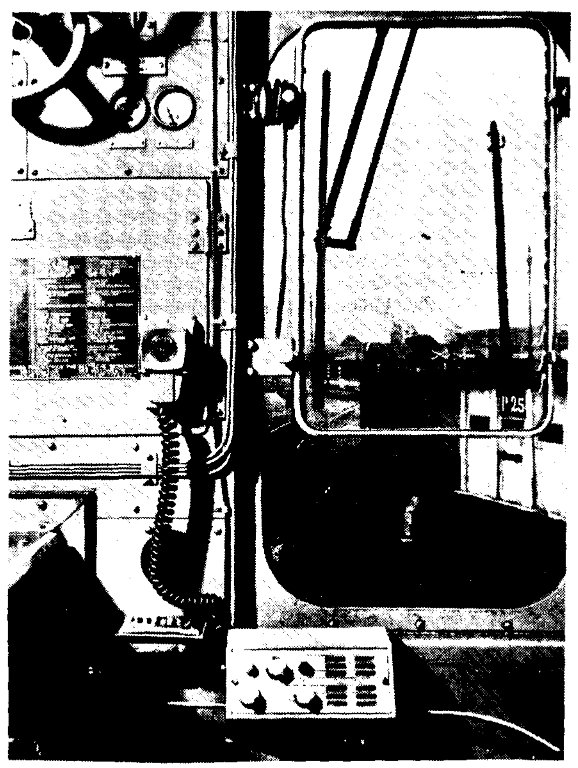
By An Engineering Correspondent

BELGIUM

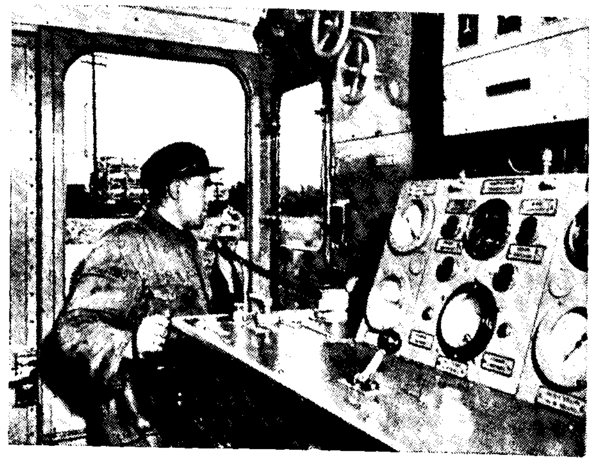
ONE of the first major locomotive radio telephone installations carried out by Pye Telecommunications Limited of Cambridge was for the Belgian Railways. The system was installed in 1956 and engineers from the Research Department of Pye went over to Belgium to supervise the work.

The equipment fitted in the Belgian Diesel locomotives is basically the Pye " RANGER " v.h.f. mobile equipments 25 kc/s channel separation. These are provided with three channels, any one of which may be selected from the control box in the driver's cab, thereby allowing movement of the locomotives to various parts of Belgium without changing the equipment. For instance, the first system was installed at Scharbeck, the main marshalling yard in Brussels, on frequency " A " while the next marshalling yard would be working on frequency " B " another on frequency " C " and so on. As a locomotive is moved from one yard to the other it merely selects the operating frequency of the particular yard.

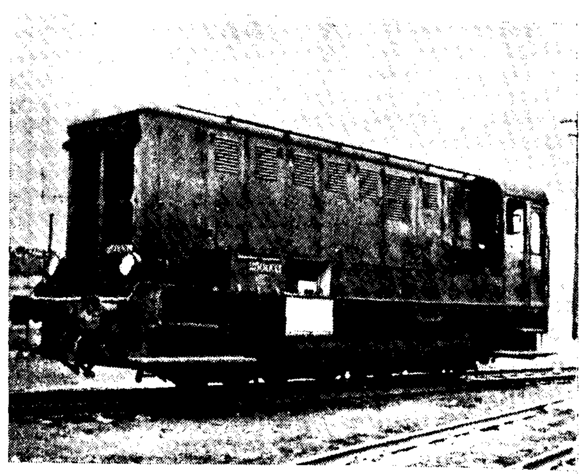
Each equipment operates from a 24 volt supply and a special voltage stabilising unit is incorporated in the set which is housed in a steel cabinet in a compartment



The radio telephone control equipment installed in the driver's cab is shown in this illustration and gives a clear illustration of its unobstrusiveness and accessibility. This equipment is duplicated in the second driving position.

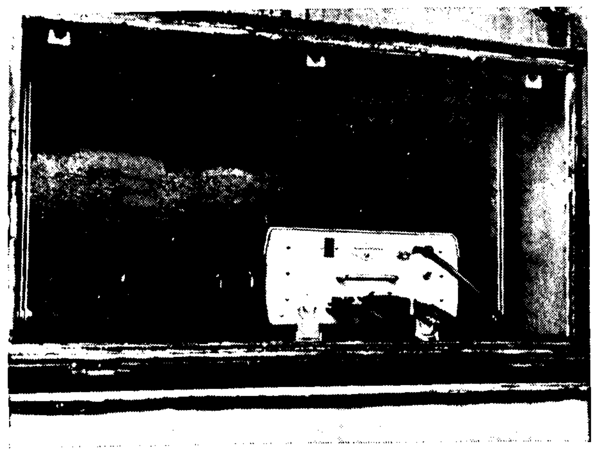


Our picture shows one of the Pye radio telephone units in use and the ease with which communication with Yard Control can be established, without interfering with the driver's normal duties.



The Pye radio telephone is seen housed in a steel cabinet on the side of the locomotive.

on the side of the locomotive. The diesel locomotive has two driving positions; one on either side of the cab, and two control boxes are provided so that the driver can operate the radio telephone from either driving



A close-up of the radio telephone unit

position. A separate re-entrant horn speaker is fitted to the back of the cab and this provides adequate volume even in the noisiest conditions.

Pye Fixed (or Base) Station units are installed in the Control Centre of each marshalling yard.

BRITAIN

The works of the Steel Company of Wales extends over an area four and a half miles long by a half mile wide and within this area raw materials are being moved continuously through the various processes necessary to produce finished steel. Steel ingots are moved by rail from the four steel producing shops to the rolling mills.

Forty-five locomotives, each fitted with Pye radio-telephones are the most important units in the haulage fleet—pulling huge ladles of molten iron from the blast furnaces to the steel melting shops. The molten iron is poured into moulds, the largest mould giving an immense ingot of twenty tons. Bogies carrying these ingots pass to the stripper bay quickly, so that as little heat as possible is lost on the way since the ingots have to be re-heated to rolling temperature.

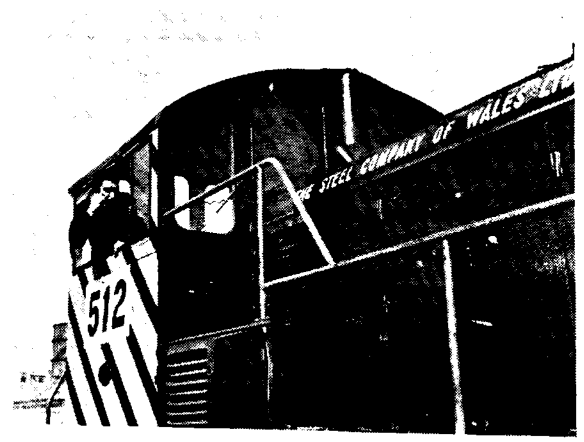
Keeping up a continuous flow of red-hot iron and ensuring that material is available at every stage of the process exactly when required, calls for careful timing and Pye Telecommunications equipment has been used at Movement Control Headquarters, Margam, Port Talbot, Wales, for a number of years.

Work has just been completed on the conversion of the Radio-telephone scheme to a two-channel network. This provides for the use of one radio channel by the Main Control and leaves a second channel free for a number of secondary controls.

A dual channel Fixed Station is connected to twelve individual radio control points and has facilities for simultaneous use of both channels. Each individual point normally controls a small group of mobiles.

By means of a dialling system, operated from each Control point, individual locomotives may be alerted by dialling the appropriate code and causing a bell to ring in the selected locomotive. The remaining locomotives on the engaged channel are automatically locked out and no other Control point may use the channel until the circuit has been cleared.

To call into the Control system from a locomotive the driver simply removes the radio telephone from the telerest in the cab and, if the channel is free, verbally alerts the required control.



Locomotive driver receiving instructions from Traffic Control

At Steel, Peech and Tozer of Rotherham, Yorkshire, England, over one million tons of steel is produced annually. Efficient control of *all* traffic within the works (an area of approximately 1½ miles long and ½ a mile wide) is achieved with the help of Pye Telecommunications equipment.

Eight steam and eight diesel engines, working on the 47 miles of rail track which serve the works, are fitted with Pye v.h.f. units, as are ten of the road

transport vehicles. These operate into three radio control points situated in :—

The Road Transport Office ;
Templeborough Melting Shop ; and
Railway Traffic Control Office,

The movement of steel ingots is controlled from this office.

thus eliminating wasteful effort, ensuring materials are speedily removed from the Melting Shop and that road and rail transport generally is utilised to the full.

INDIA

A great deal has been written elsewhere on the achievements of the Indian Steelworks Construction Company at Durgapur which has an initial target of one million tons of steel per year. Here again the radio telephone system for the locomotives was supplied by Pye Telecommunications Limited and engineered in conjunction with the British Thomson-Houston Company Limited.

Communications is provided between the traffic manager's office and each of the 13 large and 10 small works locomotives. The equipment consists of a Central (or Fixed) Station with two v.h.f. amplitude modulated transmitters of 12 and 15 watts (one is a standby unit) and mobile radio telephone transmitter/receivers for each locomotive. The traffic manager uses a remote control unit and the omni-directional aerial assemblies are mounted on one of the work's floodlighting towers.

(Continued on page 40)

RAILWAY SIGNALLING IN INDIA AND BRITAIN

By Kenneth Cantlie, M. I. Mech. E.

INDIA'S first railways were built and staffed by engineers from Britain, where railways were invented more than 100 years ago. The association formed then between the railways of the two countries has continued right up to the present day and some Indian railway technicians still go to Britain for training.

Over the years, however, the Indian railways have developed features of their own, and signalling is one of the aspects of railway work which has evolved characteristics particularly suited to Indian methods. The term "signalling" is understood to include not only visual indications to the train crews, but also the general control of train running.

SEMAPHORE SIGNALS

The earliest signalling was done by railway policemen who gave hand, or lamp, indications to trains but, as speeds increased, mechanical signalling of various types came into use. Experience showed that the semaphore type of signalling was the best at that time, and almost all India's railways adopted it from the outset. Safety, both in India and Britain, was the prime consideration, and the signalling systems therefore remained basically in accord, for any new idea in one country was soon adopted by the other.

On double-track main lines and at large junctions the two systems were identical but there were certain detailed variations on single lines due to slight differences in operating methods. Most single lines in Britain used left-hand running at passing stations, but in India the first train to reach a crossing usually took the loop to give the second train a straight run-through. This required bracket signals at both ends of each station. Furthermore, most single lines in Britain used distant (warner) signals for the single home signals, whereas in India an outer signal was usually fitted a quarter-of-a-mile in advance of the bracket home signal to end the section and provide an overlap. As speeds increased in India a distant arm was fixed below the outer signal arm to indicate a clear run-through. Latterly, these warner arms have been separated from the outer and placed half-a-mile in advance. The Indian and British systems are consequently now in closer accord than they formerly were, although the Indian system for single lines was, and is, more elaborate than the system in Britain and much more so than in most other countries. The Indian system, however, left little to chance and the excellent safety record of the Indian railways is the result.

BLOCK SYSTEM

The block system with full interlocking has long been in use on all the busier Indian lines, with signal cabins equipped as in Britain. At small Indian stations, ground frames with a simple type of interlocking have always been widely used, with the double-wire system in more general use than in Britain.

Token working of single lines also developed minor changes. On early single lines in Britain a train staff was used, later supplemented by tickets.

(Continued from page 39)

The equipment for each locomotive includes a 5-watt transmitter/receiver, complete with whip-type aerial. The control box and speaker are separate units, and a hand-type microphone is provided.

The system operates on two frequencies, one for transmissions from Central control, whose messages are heard by all the locomotives, and the other for transmissions from the locomotives, which are picked up only by Central control. Locomotives cannot speak to each other.

The control unit in each locomotive has an on/off switch and the system is maintained ready to receive calls whenever the switch is "on". The Central control station has, in addition, a transmit/receive switch to enable the functions to be selected.

This system was used on early Indian railways, but when telegraphic connection was established the way was paved for the introduction of token instruments. Generally, the busy single line sections came to be worked by Tyers tablet or Neale Ball-token instruments and other systems which complied with the rules laid down by the Indian Railway Board. Single lines with light traffic were, and still are, worked by telegraphic line clear or tickets.

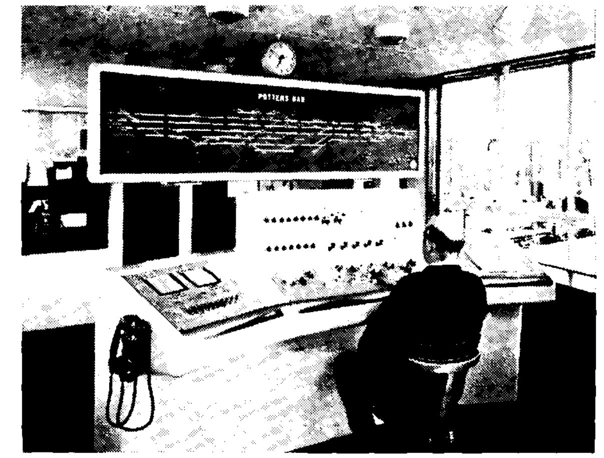
The general use of telephones on railways soon led to the introduction of the control system, by which a single control office observed and directed the running of trains. During the 1920's this system was widely introduced in India, because it was realised that on single tracks, especially those carrying heavy traffic on tight schedules, the crossing of out-of-course trains could be much better arranged by a controller. In Britain, the control office acted as an observer rather than a director and took action only in unusual circumstances. In India, however, many lines gave their controllers fuller powers. Centralised traffic control has not yet been used in India, but an experimental section is under construction on the South Eastern Railway between Hergundi and Khurda Road.

During the 1920s upper quadrant signals came into wide use on railways in Britain, but Indian lines could see little advantage in them for general use, though they adopted upper quadrant three-aspect signals on single lines to replace outer and warner arms. In latter years considerable installations of multi-aspect upper-quadrant double-wire signalling have been carried out.

COLOUR-LIGHT SIGNALS

Power operation of points and signals has been used at the busiest junctions and stations in Britain since the 1900s, but was adopted in India only when big re-signalling schemes, such as those that accompanied electrification, were carried out. The type of signalling then introduced was largely of the colour-light type with electric and electro-pneumatic point operation. Since then, colour-light signalling has been adopted on a wide scale in both countries. In Britain, where traffic is always heavy and the sections usually short, four aspect signalling is now usual, but India uses both three and four aspects as circumstances may dictate.

Tokenless train operation is to be tested in India between Siliguri and Amingaon on the North-East Frontier Railway, and, successful, will doubtless be widely used as it speeds up single-line traffic by making it unnecessary to reduce speed through



A view of a new signal box on British Railways which is now involved in a big Modernisation Plan, the cost of which was estimated by the Railway authorities in 1957 to reach £ 1,660,000,000 over 15 years.

stations to pick up and drop tablets. Britain has not found tokenless working necessary as she has a satisfactory system of mechanical exchange.

AUTOMATIC CONTROL

Automatic train control was first adopted on a wide scale by the London Underground railways, using the mechanical trigger system. About 1906 the then Great Western Railway in Britain introduced what it called an automatic warning system which applied the brake whenever a distant or warner signal was passed at danger. This is a contact ramp system which is rendered inoperative by a current of electricity. An inductive warning system is being installed as part of the Modernisation Plan for British Railways, which put the cost at £20,000,000 (Rs. 27 Crores) out of a total for signalling and telecommunication of no less than £100,000,000 (Rs. 133 crores).

An automatic train control committee was set up in Bombay in 1946, headed by Sir George Cuffe, General Manager of the Bombay, Baroda and Central Indian Railway, and consisting of officers of that line and also the Great Indian Peninsula. Two types of inductive systems were tested on sections of both railways with, in addition, a contact ramp system of

Long Welded Rail Laying on British Railways

By An Engineering Correspondent

HYMATIC MOBILE COMPRESSORS SUPPLY VITAL POWER

The maintenance, periodical overhaul and relaying of sections of Britain's railways provide a vital contribution towards the safety and comfort of millions of people and British Railways engineers have therefore to maintain a continual inspection and relaying service over the many hundreds of miles of line throughout the land.

On the North-Eastern Region the system adopted by the Chief Civil Engineer for laying 600 ft. long welded rails into the track is to draw the rails in pairs from the special wagons on which they are conveyed from the Welding Depot to the site, straight on to their final positions on the sleepers in one operation.

A week before the time for laying the long welded rails, concrete sleepers are laid in the track, using service rails to position them correctly in prefabricated track lengths. Hymatic-Hydrovane compressors, type 98 P 100, manufactured by The Hymatic Engineering Co. Ltd. of Redditch, Worcs, are used to operate impact wrenches for removing and replacing the sleeper/rail fastenings. Mounted on a lightweight rail trolley specially adapted for carrying it, each Hymatic compressor provides the power for operating two of these tools, four compressors in all being employed at a time.

The first operation is to remove all the fastenings from the service rails except those on every fifth sleeper, which retain the service rails until the rail-carrying train passes over them. The first two Hymatic-Hydrovane compressors move on their trolleys ahead of the long rail train and the fastenings are removed. Then follows the train, off-loading the 600 ft. rails in pairs. The second two compressors, operating four more impact wrenches, follow the train to refix the fastenings.

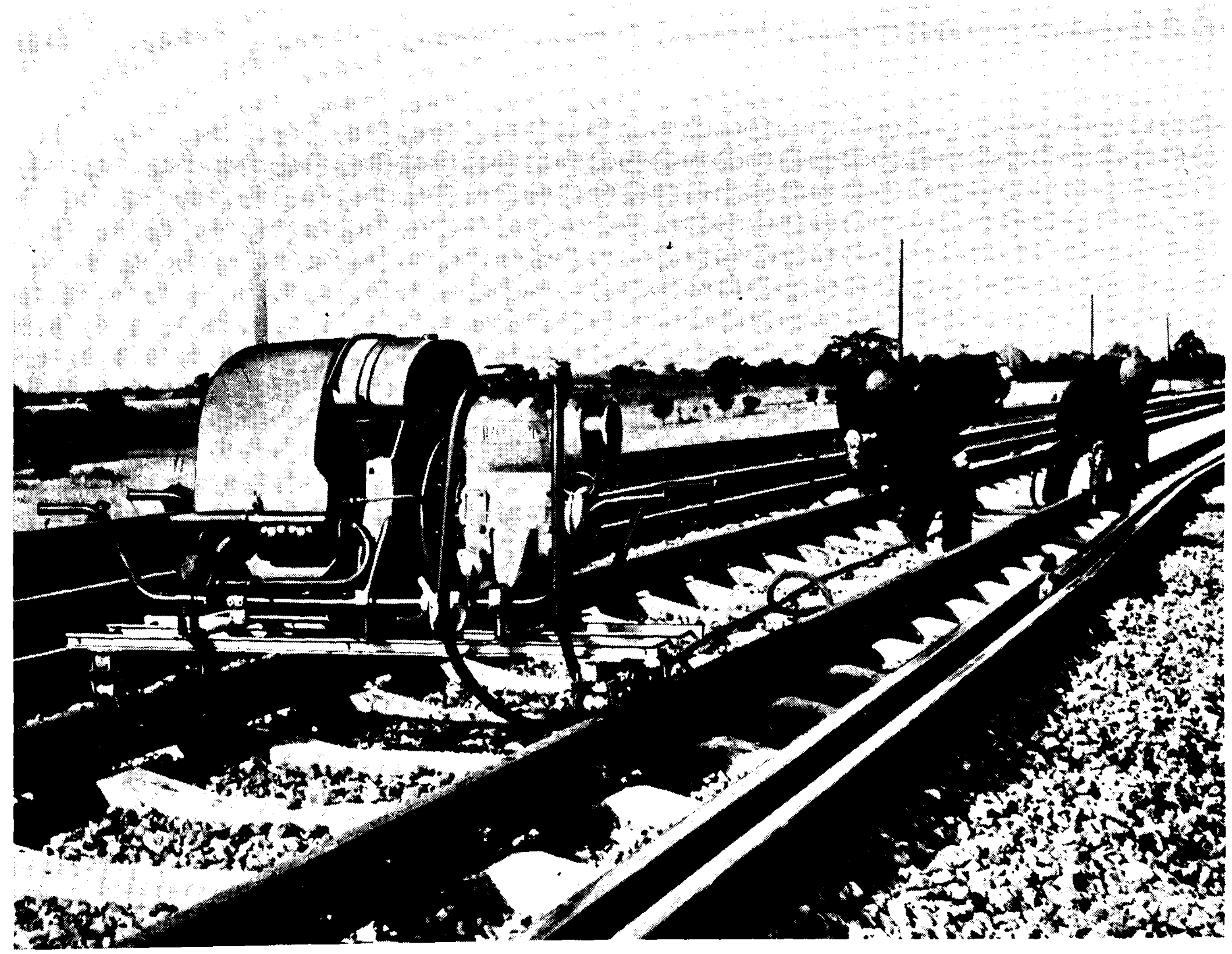
In total, some 8448 fastenings are undone and refixed for every mile of long welded rail laid in the track, the overall rate of laying being between 200—300 yards per hour. The 98 P 100 Hymatic-Hydrovane compressors provide the power for this essential task and are key tools on the job. They are also widely used for other permanent way maintenance work.

* * *

HAPPY START TO THE NEW YEAR FOR HYMATIC

£ 20,000 Hydrovane order from South Africa

It has been a good start to 1962 for The Hymatic Engineering Co. Ltd., of Redditch, Worcs, with an order worth £ 20,000 to supply 40 Hydrovane Mobile Air Compressors type 98 P 100 to the South African Railways, gained in the face of international competition. It follows successful operational results of several compressors by the South African Railways.



The maintenance, overhaul and re-laying of sections of Britain's railways is now being carried out by using a Hymatic compressor, type 98 P 100 which has been mounted on a trolley. This makes it a much quicker operation than previous methods.

Hydrovane compressors have proved ideal for work in South Africa where often the going is hard. The fact that much of the country is plateau land causes difficulties with some compressors due to the falling off in engine power with altitude. Engine power is also reduced considerably by the high atmospheric temperature, particularly in coastal areas. The 98 P 100's however, with an output of 72 c. f. m. at 100 p. s. i. which is sufficient to operate continuously two spike-drivers, four tie-tampers, two impact wrenches or one heavy pneumatic tool such as a concrete breaker or rock drill, give an excellent performance from tropical lowlands to altitudes up to 6,000 ft. This is made possible by the high efficiency of the Hymatic Hydrovane compressor and the power margin which is provided by the engine.

Weighing only 588 lb. and with handles at each end and a detachable under-carriage, the 98 P 100 can easily be pushed and man-handled over rough ground—or carried bodily if necessary.

The compressors will be used mainly for track maintenance work, for their compactness and exceptional manoeuvrability make them specially advantageous for use in cuttings and on embankments.

(Continued from page 41)

the type used on the Great Western Railway of England. All three types proved technically successful, but the inductive system was found, impracticable because of lineside pilferage and the ramp system was regarded as inferior technically to the others. Further experiments were postponed.

The Modernisation Plan for British Railways is the greatest single plan in the history of railways and is intended to make the railways of Britain second to none. The sum required was estimated by the railway authorities themselves in 1957 to be £1,660,000,000 (Rs. 2,158 Crores) over a term of 15 years. The Indian railways have always taken the keenest interest in the Modernisation Plan and when a conference was held in London in May 1961 to review the first six years of the plan, Shri Karnail Singh, Chairman of the Indian Railway Board, was a welcome participant and gave wise advice, which received the closest attention.

It can, therefore, be seen that in signalling as in other phases of railway work, the old-established friendship between the Indian and British railways continues, with great mutual benefit.

401 Series Silicon Rectifier System A.C.-D.C. Electric Multiple Unit Coaches

[The 401 series A.C.-D.C. electric multiple unit coaches are the self-propelled electric coaches designed for service on a line which includes the sections of both A.C. and D.C. system. Using latest technical developments including silicon rectifiers and A.C.-D.C. changeover circuits which are activated aboard the train, the coaches of this series are the first A.C.-D.C. dual system electric coaches to be manufactured in Japan.]

INTRODUCTION

As a result of several years of research work, the future standard for the electrification system of Japanese National Railways has recently been set for A.C. 20 kV of commercial frequencies of 50 cycles and 60 cycles, instead of D. C. 1,500 V as hitherto. Already, some parts of the Senzan Line, Hokuriku Line, Tohoku Line, Joban Line and Kagoshima Line have been electrified under the A.C. system.

In all these lines, newly electrified A.C. sections have to be connected with the already established D.C. sections. Electric coaches serving on these lines which have dual electrical systems must be capable of operating in both sections of the electric systems. The 401 series A.C.—D.C., E.M.U. coaches were designed for this purpose, and are to be commissioned first on the Joban Line. A prototype train was manufactured in June 1960, and mass produced coaches of this type started coming off the production line in the spring of this year.

Hitachi, Ltd. is well experienced in the manufacture of not only D.C. electric cars but also A.C. cars. In the manufacture of the 401 series coaches, the company took maximum advantage of the experience which

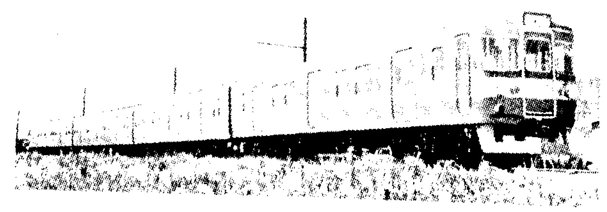


Fig. 1. Outside View of 401 Series A.C.-D.C. E.M.U. Coaches

had been accrued in producing the ED 46 type A.C.—D.C. electric locomotive.

GENERAL CONSIDERATIONS

These electric cars are designed to run through sections of two differing electrical systems on the Joban Line. The Line, partly electrified in A.C. 50 cycle 20 kV, has an earlier electrified section of 1,500 V D.C.

The features of the 401 series coaches are listed below :

1. These coaches are always operated in a train of 4 coaches as one operating unit, and as

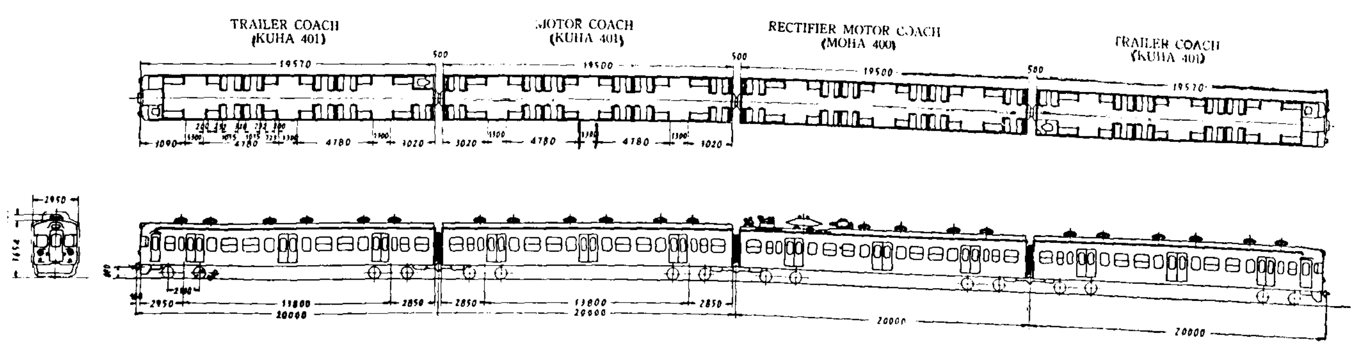


Fig. 2. 401 Series Electric Multiple Unit Coaches

the occasion may demand, can be operated in long trains consisting of 2 to 3 units. Of the four coaches forming one operational unit, those at each end are trailer coaches. One of the motor coaches is the power supply coach in which is located all the necessary A.C. high tension equipment.

2. In the A. C. section, the A. C. overhead current is rectified into D.C. 1,500 V to drive the main motor. The rectifier used is the silicon rectifier.
3. While the train is running, the driver can effect a changeover from A.C. to D.C. operation or vice versa.
4. All the high voltage equipment for the A.C. circuit is located on the roof of the coach, while the main transformer, silicon rectifiers and other equipment are installed under the floor.

The main specifications of these electric multiple unit coaches are given in *Table I*. *Fig. 2* shows their external appearance.

CAR BODY

The car body frame and underframe are of light weight monocoque structure which is an assembly of light gauge steel and pressed steel plates welded together. The side panel is of 1.6 mm thick cold rolled steel sheets while 1.2 mm thick cold rolled steel sheet is used for roofing. The side post, carline and cross beams are arranged on the same cross section in a circular layout. The center sill of the underframe is installed outside the bolsters only and not between the bolsters. Instead, a corrugated keystone plate covers the entire area of the upper surface of the underframe in a longitudinal direction. Shocks inflicted on the ends of the coach are to be borne by this keystone plate and the side frame.

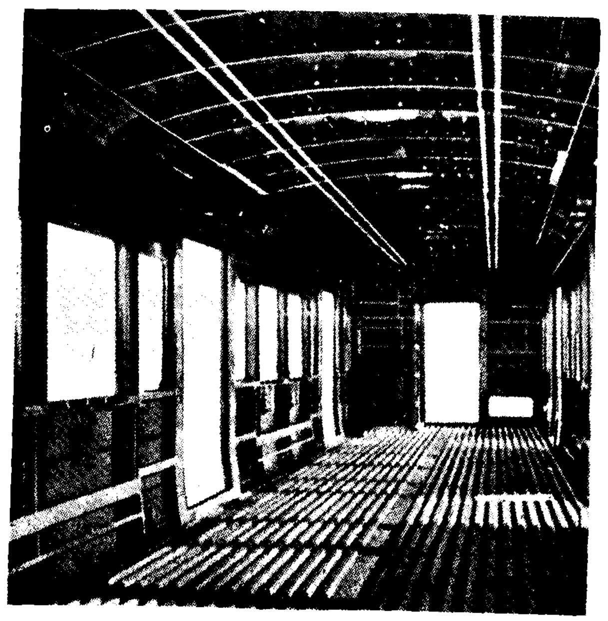


Fig. 3. Interior View of Car Body Structure

TABLE 1.

Comparison of Space Factor for Each Type of Core Based on Internal Area of Coil.

1.	Passenger capacity and empty weight :	
	2nd class control coach (KUHA 401)	116 passengers 30 tons
	2nd class motor coach (MOHA 401)	128 passengers 37 tons
	2nd class motor coach (MOHA 400)	128 passengers 42 tons
2.	Performance of 1 unit of motor coach :	
	1 hour rated output	775 kW
	1 hour rated tractive effort	
	70% field	59.6 km/h
	40% field	78.6 km/h
3.	Maximum operation speed	95 km/h
4.	Drive wheel diameter	860 mm
5.	Gear ratio	17 : 82—1 : 4.82
6.	Traction motor	MT 46 B, 375 V, 100 kW, 300 A, 1,860 rpm
7.	Main transformer	For suspension under the floor ; radial core type; continuous rating of 807 kVA.
8.	Rectifying system	Forced ventilation type silicon rectifier
9.	A.C.—D.C. change-over	Simultaneously power off and power on : in sequence
10.	Control system	Series-parallel, field weakening, multiple unit control rheostatic brake
11.	Braking system	
	Motor coach	Combined automatic and electromagnetic straight brake with rheostatic brake
	Control coach	Combined automatic and electromagnetic straight brake, and hand brake

The passenger room has a ceiling of 1.6 mm thick aluminum alloy sheet coated with white melamine plastic paint. The inside of the room is paneled with melamine plastic coated board of light green color. Melamine plastic board requires little maintenance care because it needs no painting, stains are easily removed, and it is difficult to damage. The floor consists of a 15 mm thick veneer board covered with vinyl chloride sheet.

Special consideration was given to the arrangement of the passenger rooms of these A.C.-D.C. E.M.U. coaches because these coaches in view of their service area, serve not only as commuter trains but also as inter-urban trains. To elaborate, 3 entrances each measuring 1,300 mm in width are installed on each side. Seats are arranged in the longitudinal direction while there are cross seats between them and towards the car ends.

A total of six chimney type ventilators are installed in the roof of each coach. Fans are installed on the ceiling of the passenger room. High voltage equipment prevents the installation of ventilators on the low roof part of the power supply coach and due to the low ceiling, it is also impossible to install fans on the ceiling. Instead, " chandeliers " are installed there.

The space between the roofing plate and ceiling board at this part serves as a wind duct which takes in fresh air from inlets opening on both sides of the roof. For heating during the winter season, an electric heater is installed under each seat.

The window frame is made of extruded aluminium. The window, divided into upper and lower parts, is opened by lifting each of the parts upward. The window is fully opened when both parts have been lifted. Each side entrance consists of two sliding doors opening in opposite directions. The sliding doors are simultaneously opened and closed by a single door engine which is installed above the door. All doors of a train are opened and closed simultaneously by the conductor in the conductor's cabin.

A novel device in this coach is the disposer installed in the lavatory. In this disposer, a disc is revolved at high speed by motor to pulverize human excreta. It is then reduced to a harmless and odorless fluid by the addition of a chemical liquid for release outside the coach.

TRUCK

The DT 21 B type truck is used in the motor coach and TR 64 type truck in the trailer coach. The DT 21 B type truck is roughly identical with the TR 64 type truck except that it has a main motor.

The three point support system involving a center plate and side bearer is utilized. The center plate bears 80% of the entire load and the side bearers 20% and a swing bolster is also used. For a smooth sliding effect, the side bearers are treated with molybdenum disulphide.

The truck frame is of H shape, without an end beam. It is made of 9 mm thick ordinary steel plate pressed into one body and assembled by welding.

Measuring 860 mm in diameter, the wheel is made of solid rolled steel. Double roller bearings are used.

Coil springs are used for the bearing springs and bolster springs. Vibration absorbing rubber is used with the bearing springs and the oil damper with the bolster spring for greater riding comfort.

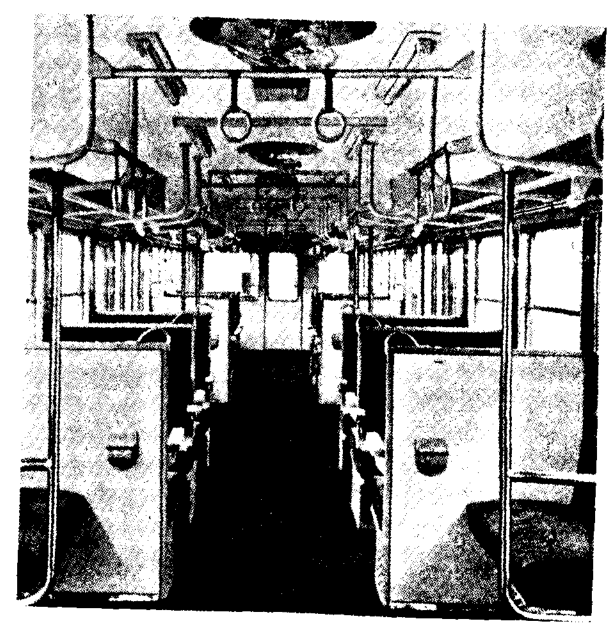
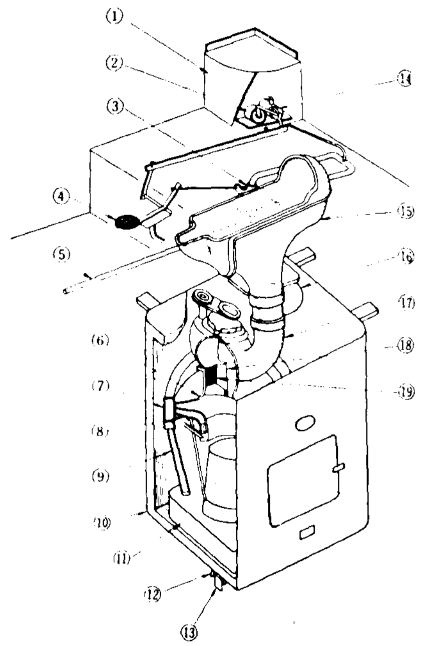


Fig. 4. Interior of Coach



1. Processing Liquid Tank
2. Time Switch
3. Flush Valve
4. Pedal
5. Fleaning water
6. Upper Body
7. Drain Duct
8. Disc
9. Pipe
10. Cold Shielding Material
11. Tank
12. Basket
13. Drain Pipe
14. Processing Liquid Valve
15. Stool
16. Drive
17. Introducing Duct
18. Moving Blade
19. Pulverizing Section

Fig. 5. *Disposer*

The braking system employs brake shoes throughout. Those used on the TR 64 type truck are of cast iron, while those used on the DT 21 B type truck are of a resinous material which functions well with rheostatic brakes.

BRAKING SYSTEM

The braking system uses SED type which combines the automatic and electromagnetic straight brake with the rheostatic brake. The main part of this brake is the electromagnetic straight brake. The rheostatic brake is used together with this brake in the motor coach. The automatic brake works when there is trouble in the electrical circuit of the electromagnetic straight brake, when the conductor's valve is operated or when the coupling between coaches is disconnected.

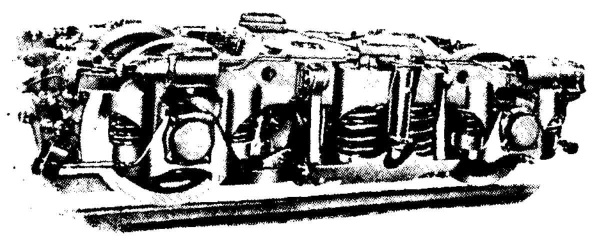


Fig. 6. Motor Truck

Mutual changeover between the rheostatic brake, the electromagnetic straight brake, and the automatic brake actions are all brought about by a single brake valve handle. The electromagnetic straight brake of this unit has a self-lapping mechanism. The braking force is maintained automatically at a constant value according to the angle of the brake valve handle. Hand brakes are installed at both ends of only the KUHA 401 to be operated from the conductor's cabin.

ARRANGEMENT OF ELECTRICAL EQUIPMENT

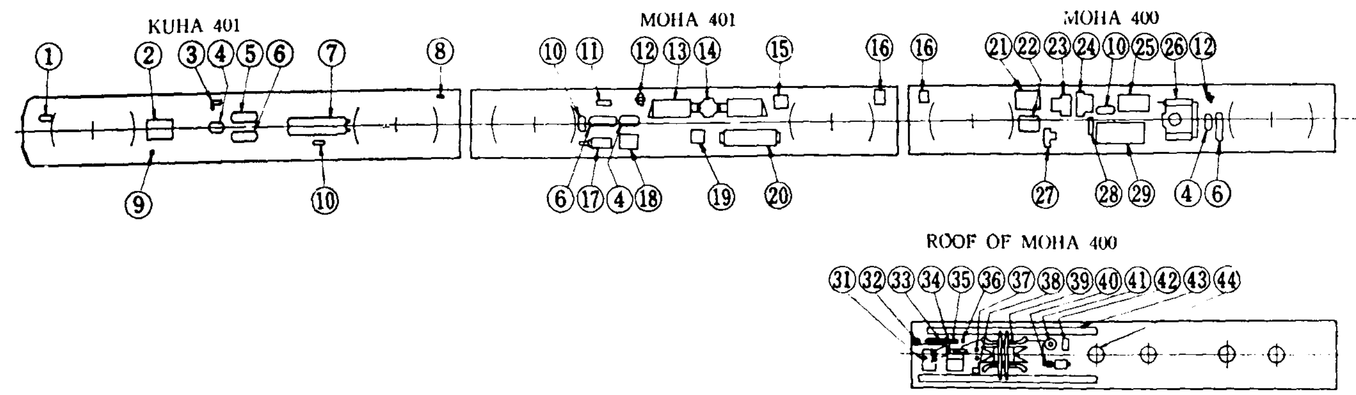
All the equipment for the alternating high voltage current is installed on the roof of the MOHA 400 coach. Other alternating current equipment such as the transformer and silicon rectifier is suspended under the floor of the MOHA 400 coach. D.C. equipments such as the main controller, main resistor and motor generator are concentrated in MOHA 401 coach.

In consideration of the limit gauge, that part of the roof of the MOHA 400 coach where equipment is installed is lower than the other part of the roof. The A.C. high voltage current is conducted from the cable head to the transformer under the floor by a special high voltage cable. The portion of this cable which descends below the floor must be protected from damage in case of an accident. For this purpose, the cable is routed through the end post which is formed in a sturdy box shape.

Fig. 7 shows the arrangement of the main equipment and *Fig. 8* the installation of the equipment on the roof of MOHA 400 coach.

ELECTRICAL SYSTEM

A schematic diagram of the power circuit is given in *Fig. 9.* These E.M.U. coaches contain the silicon rectifier system and can be operated by either A.C. or D.C. When the train is operating in the A.C. 1-phase 50-cycle, 20 kV section, the voltage is stepped down by the main transformer, rectified in full wave by the silicon rectifier and is then used to drive the series wound D.C. traction motors and the auxiliary motors. In the D.C. section, D.C. 1,500 V is taken directly from the trolley wire to drive the traction motors and others.



1. Equalizing Reservoir
2. Air Compressor
3. C-2 Brake Control Device
4. Auxiliary and Supplementary Reservoir
5. Main Reservoir
6. Suppling Reservoir
7. Water Tank
8. Disposer
9. Multiplier
10. Control Air Reservoir
11. Voltage Stabilizing Device Box
12. C-1A Brake Control Device
13. Main Resister
14. Motor Fan
15. Inductive Shunt
16. Connection Box for Main Circuit
17. Motor Generator
18. Starting Equipment for M-G
19. CB-13A Circuit Breaker Box
20. CS-12B Main Control Box
21. A.C./D.C. Change Over Switch
22. Main Reactor
23. CB 12A Circuit Breaker Box
24. A.C. Filter
25. Battery Box
26. Main Transformer
27. Aux. Circuit Breaker for D.C. Auxiliaries
28. Current Minimizing Resistor
29. Silicon Retifier
31. A.C. / D.C. Disconnecting Switch
32. Cable Head
33. Main Fuse
34. Air Blast Circuit Breaker
35. D.C. Arrester
36. C.T.
37. Air Duct Insulator
38. Eathring Switch
39. Pantograph
40. P.T.
41. A.C. Arrester
42. Resistor Box for D.C. Voltage Relay
44. Ventilater

Fig. 7. *Arrangement of Equipment*

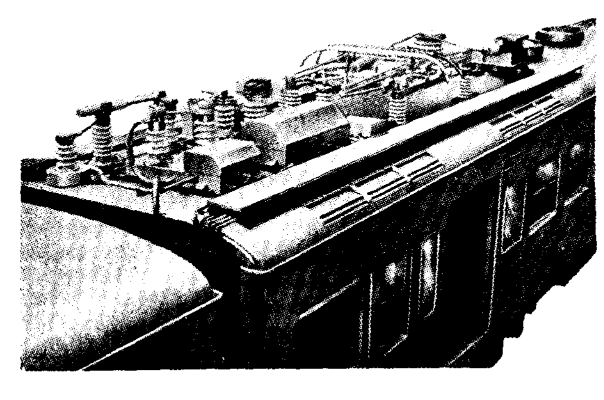


Fig. 8. Equipment on the roof (MDA 400)

The changeover control system can be operated from the operator's cabin while the train is running. As for the changeover from A.C. to D.C. or vice versa, the main circuits of all coaches are switched off simultaneously before the train enters another current section, and upon entering the different current section, the main circuits are switched on automatically from the first unit to the last one in order. To detect A.C. or D.C., each rectifier-motor coach has a potential transformer, a D.C. voltage relay and an A.C. voltage relay so that in the different current section an air blast braker is interlocked and cannot be switched on, even when the operator has misoperated.

To insure safety even in the event that the train enters a different current system without switching over, there are complete safety devices composed of a main fuse in the D.C. section, and a D.C. lightning arrester and an A.C. overcurrent relay in the A.C. section.

The speed of the train is controlled by changes of the series-parallel connections of the traction motors, the starting resistors and the field shunting resistors. These resistors are used for rheostatic braking also.

ELECTRICAL EQUIPMENT

Pantograph

There is one pantograph of the spring raised type for each unit and it is used for both A.C. and D.C. It has a simple grounding switch on its frame so that the trolley wire can be directly grounded in an emergency.

Air blast breaker

Type : CB 102 ; Rated voltage : A.C. 24 kV, D.C.

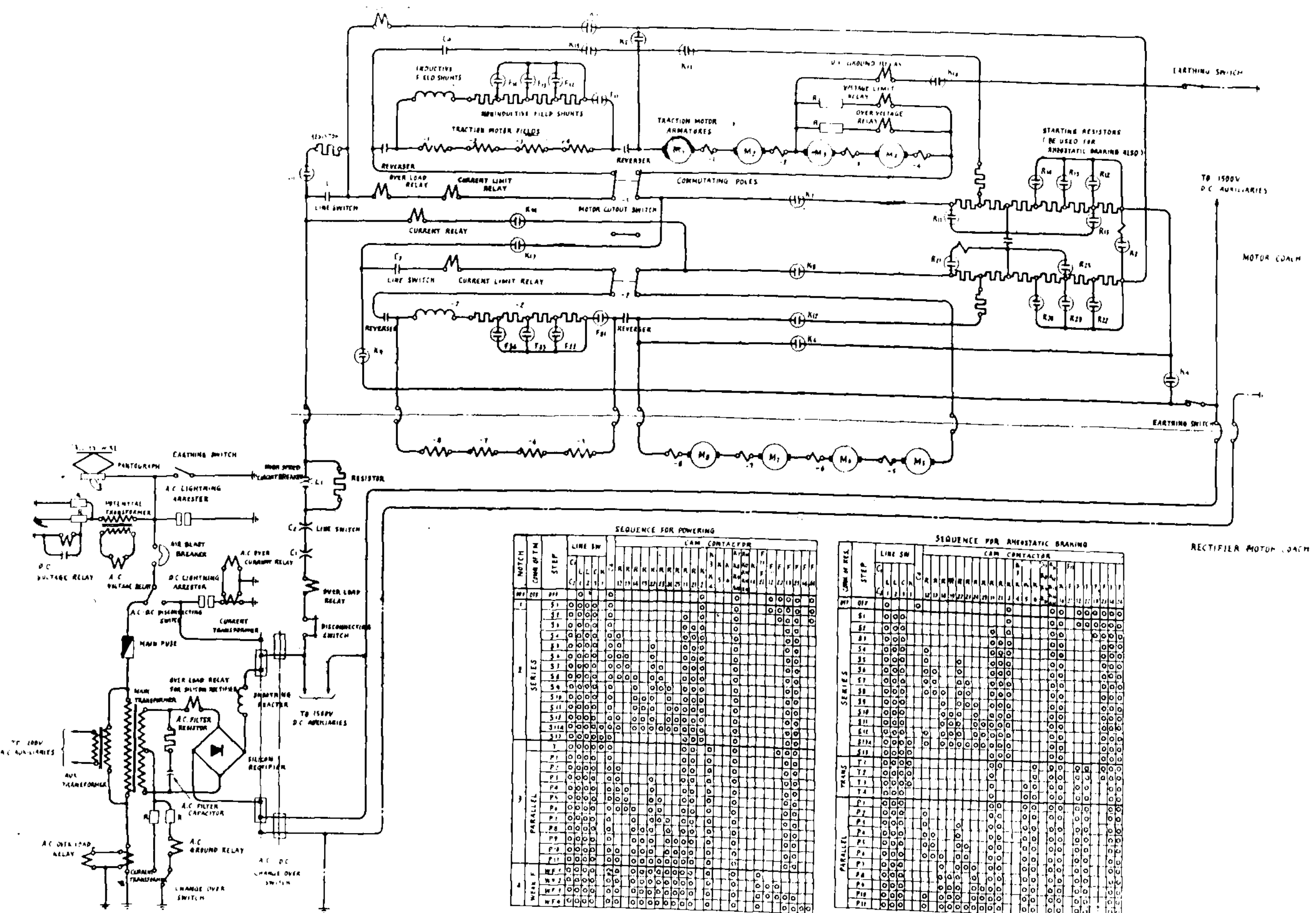


Fig. 9. Schematic Diagram of Power Circuit

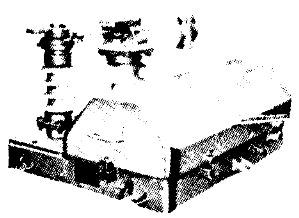


Fig. 10. Type CB 102 Air Blast Breaker

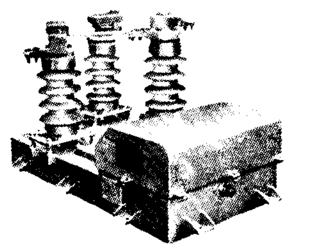


Fig. 11. Type SH 1400 HC D.C. Disconnecting Switch

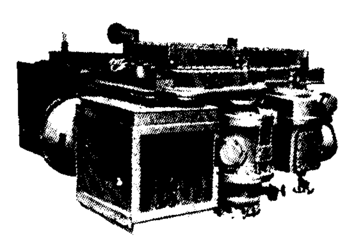


Fig. 12. TM-2 Main Transformer

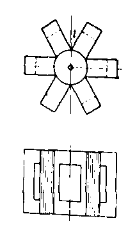


Fig. 13. Structure of Radial Core

1,500 V ; Rated current : A.C. 200 A, D.C. 600 A ; Rupturing capacity : 100 MVA, 50 cycles ; Rupturing time : 0.06 sec.; Rated air pressure : 7 kg/cm².

Fig. 10 shows the outside view of this air blast breaker. The operating mechanism is accommodated in a waterproof case for installation on the roof. Structurally, it can sufficiently withstand repeated use.

A.C.—D.C. Disconnecting Switch

Type : SH 1,400 ; Rated voltage : A.C. 23 kV, D.C. 1,500 V ; Rated current : A.C. 200 A. D.C. 800 A ; Rated air pressure : 5 kg/cm.² Intended for installation on roof, the operating mechanism is accommodated in a waterproof case. *Fig. 11* shows its external appearance.

Transformer

Type : TM-2 ; Continuous rating : 807 kVA/800 kVA, 20 kVA/1,820 V ; Auxiliary transformer : 7 kVA 20 kV/210 V, 50 cycle ; Insulation oil ; non-inflammable oil "Hitafunen".

The main transformer is of the so-called radial core type. As shown in *Fig. 13*, yokes are arranged radially around the core. Both the primary and secondary windings are wound concentrically with the core. The contents of this transformer are placed in a round oil tank. The insulating oil is force circulated. Thus the core, windings and tank assume concentrically located cylindrical forms. This makes insulation, cooling effect and mechanical strength of the equipment superior to those of other transformers. The space factor of the core is also most excellent as shown in *Table 2*. Since this transformer can be made in small size and weight, it is ideal for use in electric coaches.

Non-inflammable oil "Hitafunen" is used as insulation oil, which has excellent electrical and physical characteristics. " Hitafunen " itself and its gas are non-explosive and barely inflammable. It is chemically stable and has considerable resistance against oxidization. Thus there is little change in its properties, and this oil can maintain its qualities for years.

Special consideration was given, in the manufacture of this transformer, to sound and vibration shielding because of its use in electric coaches. The core is made completely secure. The magnetic flux density was selected to reduce vibration. Vibration damping rubber is used in installing it in the coach.

Silicon Rectifier

Type: F-4 B; Rated capacity : 810 kW D.C. 1,350 V. 600 A continuous, 1,100 A 30 sec. Connection : 1-phase bridge. Element : Max. allowable P.I.V. 700 V Max. allowable transient impulse : 900 V. Max. allowable forward current : 200 A.

TABLE 2.

Comparison of Space Factor for Each Type of Core Based on Internal Area of Coil

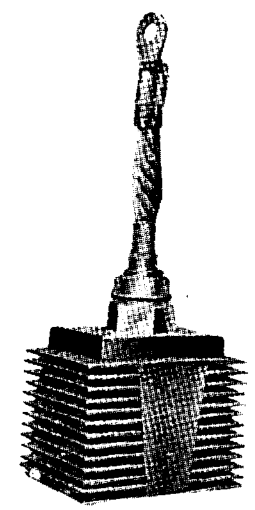
Type	Space Factor
Outside Core Type	0.74—0.76
Inside Core Type	0.74—0.82
Radial Core Type	0.84—0.9

The silicon rectifier is ideal for use in electric coaches because of its high efficiency, simple construction and lightweight, and it requires almost no maintenance.

In the silicon rectifier, the elements are a drastic improvement over elements hitherto used. As a result, the number of elements has been reduced to only 80, thereby making it possible to considerably reduce the overall size and weight.

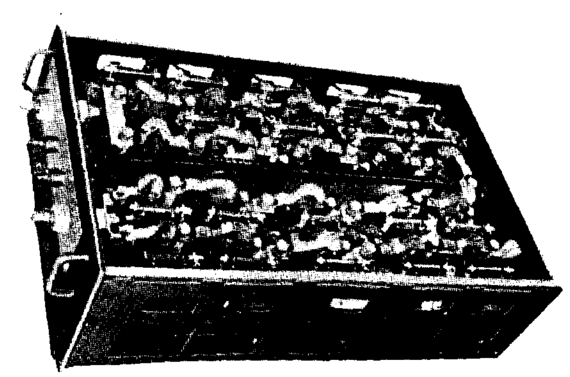
Diffusion type silicon semi-conductors are used as rectifying elements. Progress in the manufacturing process has resulted in elements of high efficiency. Improvement is noted particularly in the inverse voltage rating and there is a considerable increase in current capacity. Of particular advantage in electric coach service is the ability to withstand repeated overload.

Fig. 14 shows the rectifying element and *Fig. 15* the tray combined with elements. *Fig. 16* shows the external appearance of the rectifier box, inside which there are 8 trays and various protective devices.



←Fig. 14. Cell and Fin

Fig. 15. Rectifier Tray ↓



Prior to making a decision to adopt the silicon for these coaches, it was subjected to a strict peak load test, short period load test, intermittent load test and mechanical vibration test. As a result, it was confirmed that the equipment was sufficiently strong to withstand these tests.

Traction Motor

Type: MT-46 B; One hour rating: 100 kW, 375 V, 300 A, 1,800 rpm (70% field).

The traction motor is operated by pulsating current in the A.C. section. Therefore, a motor with special consideration for pulsating current is used for these coaches.

Due to the use of the Cardan driving system with a flexible shaft and disc, the traction motor, weighing only 735 kg, can attain a maximum speed of 4,320 rpm minimum field of 40%. Capable of withstanding operation at pulsating current of 30 to 50% current ripple, the motor is assured of excellent performance and good commutation. "A" class and "H" class insulation are used in the armature and field coils, respectively.

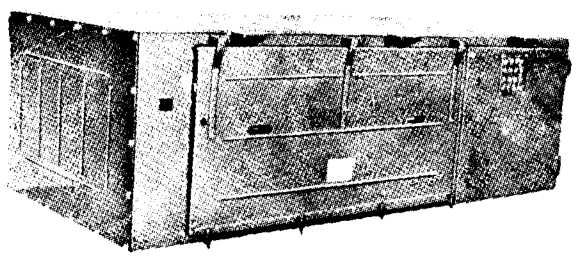


Fig. 16. Cubicle of Rectifier

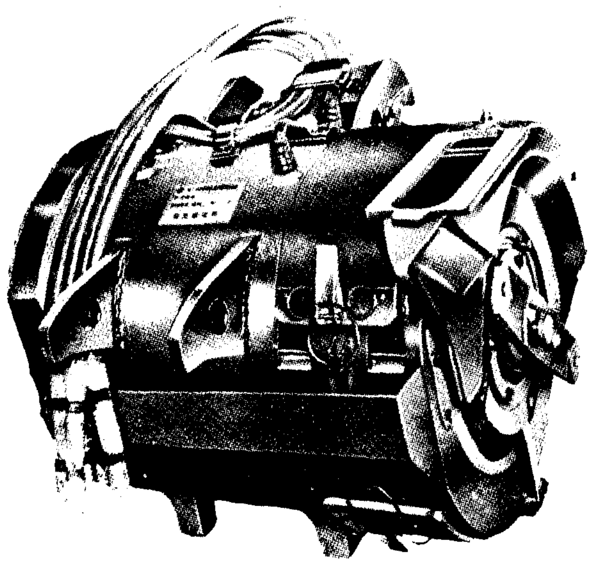


Fig. 17. Type MT 4513 100 kW Traction Motor

Fig. 17 shows the outside view of the traction motor.

Auxiliary Rotating Equipment

Like the traction motor, the 20 kVA motor-generator set and 6 kW motor compressors for the A.C. and D.C. dual system are supplied with power from the 1,500 V D.C. source. They are designed for use with pulsating current. The auxiliary motors for the silicon rectifier and main transformer cooling, to be used in the A.C. section only, are single phase condenser motors which are confirmed to be capable of meeting voltage variations of + 15 – –20%.

A.C.—D.C. Changeover Switch Box

The switch box accommodates a Type KS 6 D.C. 1,000 A continuous A.C.-D.C. changeover switch for switching over the traction motor circuit and auxiliary circuits from A.C. to D.C. or vice versa, together with protective relays, auxiliary relays and pilot lamp. *Fig. 18* shows the interior view of this changeover switch box.

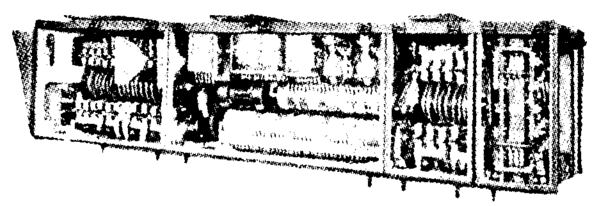


Fig. 18. A.C.-D.C. Changeover Switch Box

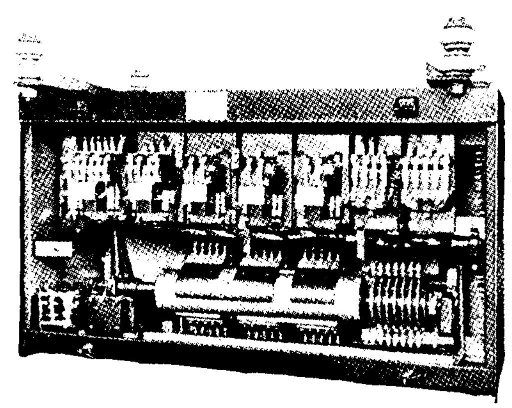


Fig. 19. Type CS 12B Motor Operated Cam Shaft

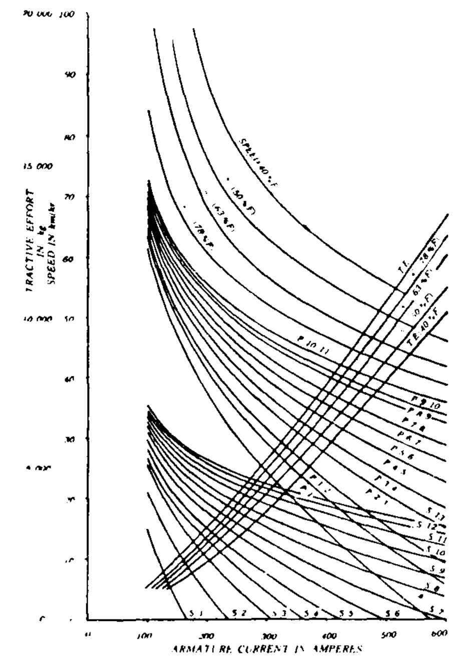


***Fig. 20.** Notching Curves for A.C. System Line Voltage A.C. 18kV c/s*

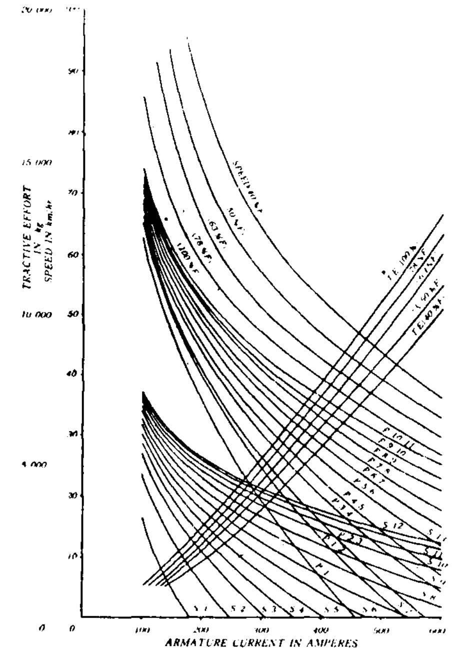


***Fig. 21.** Notching Curves for D.C. System Line Voltage D.C. 1350 V*

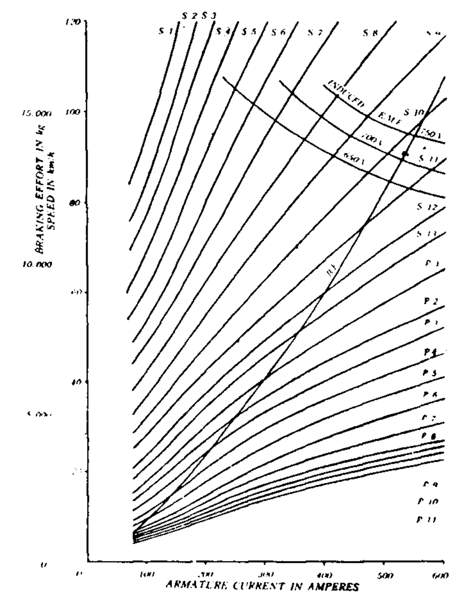


***Fig. 22.** Notching Curves for Pheostatic Braking*

Main Controller Box

This controller box is a modification of the motor operated cam shaft controller, which has been used in J.N.R's D.C. electric multiple unit trains including MOHA 100 and those developed later, for use with pulsating current. *Fig. 19* shows the appearance of type CS 12 B main controller box.

Figs. 20–22 show the notching curves.

Traction Motors for I.C.F.

India's need in respect of generators, transformers, and switchgears will be met entirely by the Heavy Electricals Plant at Bhopal after the Third Plan period, it is learnt. The other two heavy electricals, plants, will be commissioned before the end of the Third Plan with Soviet and Czechoslovakian aid.

Four hundred electric multiple units which are expected to be produced at the Integral Coach Factory Perambur, during the Third Plan period, will be supplied with traction motors and other electrical equipment manufactured at the Bhopal Plant.

This year's production of transformers, switchgears capacitors etc., will be worth Rs. 3.5 crores and next year Rs. 9.5 crores. The factory will start production of heavy industrial motors upto the maximum horse power of 2,000 in 1961 and motors upto 5,000 horse power in 1962. In October 1962 the factory will begin manufacturing hydro-turbines and generators.

* * *

Consultants for Steel Foundry at Chittaranjan

Mr. F. N. Lloyd, chairman of F. H. Lloyd & Co. Ltd., of Wednesbury, Staffordshire, accompanied by three members of his firm, will arrive in New Delhi on January 24, 1962.

F. H. Lloyd & Co. are the consultants to the Indian Railway Board for the steel foundry being set up at Chittaranjan, West Bengal. The firm is also helping in the training of Indian personnel to manage and supervise the foundry, which will produce steel castings needed for locomotive manufacture at Chittaranjan.

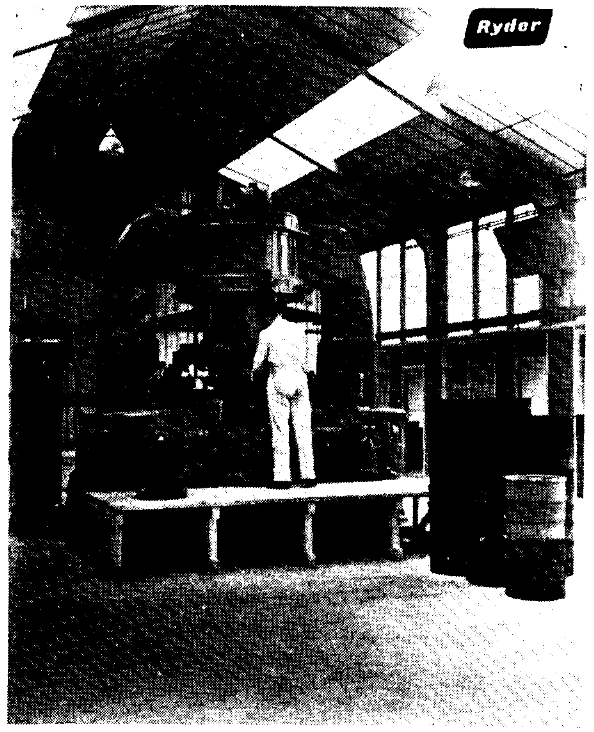
Before proceeding to Chittaranjan to see the progress made at the foundry, Mr. Lloyd and his colleagues will attend the Republic Day celebrations in New Delhi.

F. H. Lloyd & Co. is an old-established firm of steel-founders and engineers, producing steel castings of all kinds weighing from a few pounds to 30 tons for many industries, including shipbuilding and railways.

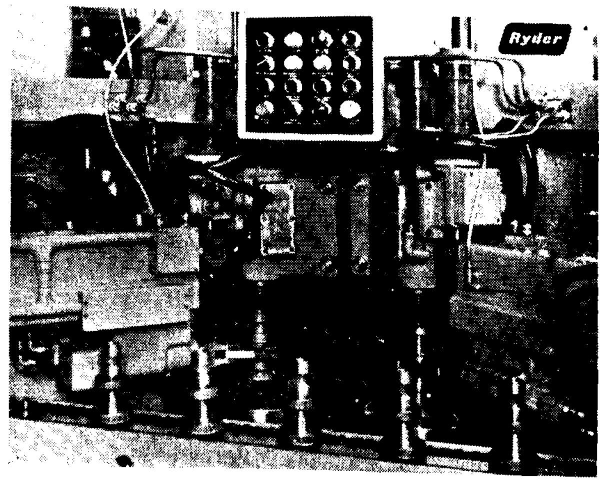
* * *

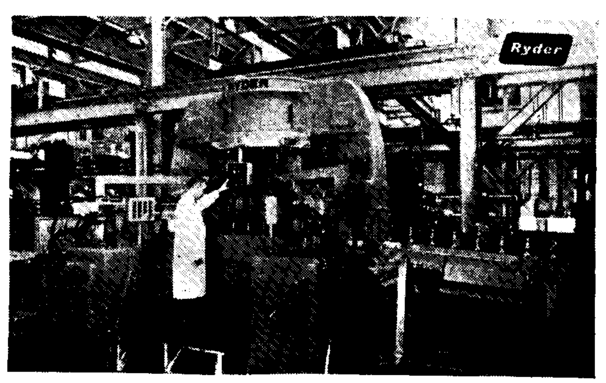
RYDER VERTICAL CHUCKING AUTOMATICS

THE single—and multi-spindle automatic lathes manufactured by Thomas Ryder & Son Ltd., of England, are fundamentally different from their conventional counterparts in that they hold the workpiece vertically, instead of horizontally. By this means, easier loading and valuable saving of floor space are achieved. Unskilled labour can be employed for, once the work is chucked and the

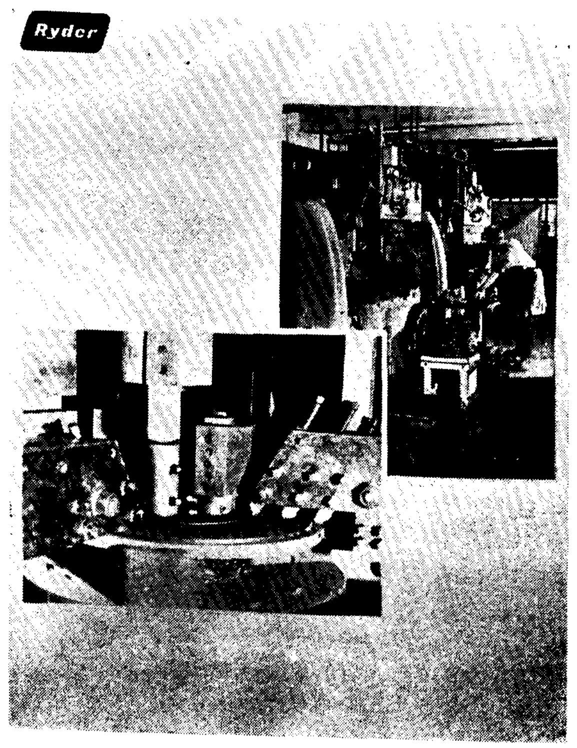


No. 10 Verticalauto
Tooled for machining Pistons





No. 10 Verticalauto
Tooled for machining Vauxhall Layshaft Gears and fitted with Automatic Loading Attachment

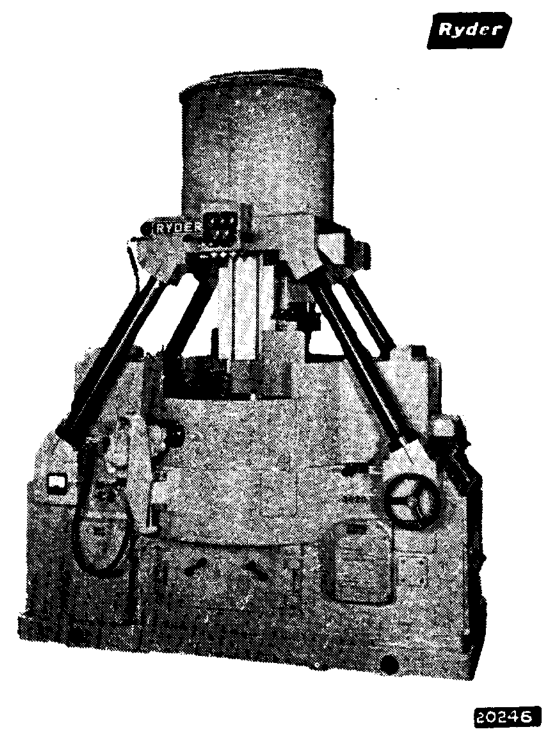


No. 18 Rydermatics
Tooled for machining Tractor Clutch Plates at Ford Motor Co. Ltd.

machine started, the cycle of operations which follows is fully automatic. The operator is very carefully protected by many interlocking safety devices.

The single-spindle lathe is known as the Rydermatic, available in three ranges: the No. 12, No. 18 and No. 18/30, each suitable for pneumatic chucks of either 15" or 18" diameter. All these machines can be supplied either as two-slide models with one vertical slide and one horizontal facing slide, or as three-slide models having the addition of a universal slide. An air-operated tailstock can be fitted.

The Ryder vertical multi-spindle automatic is called the Verticalauto—in five types to cover a very wide range of work. With the aid of the Verticalauto and various attachments many machining operations—normally considered beyond the scope of multi-spindle automatic machine tools—are performed regularly at high production rates. Such operations include multi-drilling, tapping, cross drilling, milling, electro-hydraulic profiling and automatic loading.



No. 6 Verticalauto

The five types of Verticalauto are referred to as: No. 6, No. 8, No. 10/6, No. 10/8 and No. 10/12.

The No. 6 and No. 8 are similar in design, with

OXYGEN IN INDUSTRY

By C. HAWKINS, B.Sc.(Lond)A.M.I.E.E. etc.
Director and Chief Executive-Operating, Indian Oxygen Limited

DEVELOPMENTS in the industrial applications of oxygen during the last 75 years has brought about a corresponding expansion in the field of commercial production of this gas. Some of the recently developed methods of air separation and the uses of oxygen are described in this article.

Oxygen has been known to scientists for very many centuries but it was not until 1775 that a Swedish Chemist Scheele isolated this gas and investigated its properties. About the same time, Priestley of Birmingham was successful in producing oxygen in small quantities by Chemical methods. The modern system of oxygen production is by liquefaction of air and subsequent rectification of the liquid air produced.

Liquefaction of air depends upon reducing the temperature of air which is accomplished either by "Joule Thompsons' Effect", whereby air under high pressure when throttled through a valve will show a temperature reduction, or by a machine such as an expansion engine or expansion turbine. By arranging for continuous exchange of heat between incoming high pressure air and outgoing air after expansion, progressive decrease in the absolute temperature can be effected until finally part of the outgoing air is sufficiently cooled to precipitate as liquid.

Commercial application of this phenomenon involves introduction of all practical means to :

(1) Prevent entrance of heat from outside the apparatus.

(2) Affect heat exchange between stream circulating within the equipment.

and (3) Purify air prior to processing so that traces of disturbing impurities do not interfere with the continuous operation. These mainly refer to freeing the compressed air from carbon dioxide and moisture.

Plants built for this purpose incorporate Air compressors, Carbon dioxide scrubbers/absorbers, Alumina driers, Tubular heat exchangers, Rectification column units and multitube condensers. Here it is not intended to elaborate on the technical details of these units but merely to enlarge on the broad principles involved in the process.

The separation of liquid air, which is of course a mixture of oxygen (21%), Nitrogen (78%), Argon (0.9%) and other rare gases (0.1%), is effected by continuous distillation. This is made possible by the difference in the boiling points between Oxygen and

(Continued from page 55)

six vertical spindles, five working stations and one loading station ; with a vertical turning slide at each working station and a horizontal facing slide at four stations. The No. 6 Verticalauto is powered by a 15 h. p. electric motor and normally has 9″ diameter chucks ; the No. 8 has a 25 h. p. motor and 12″ diameter chucks.

The three versions of the No. 10 Verticalauto are : No. 10/6, with six spindles, and equipped with 17″ diameter chucks, six vertical turning slides (of which five are normally used) and four horizontal facing slides ; the No. 10/8 with eight spindles, 14″ diameter chucks, eight vertical turning slides (seven normally used) and four horizontal facing slides ; the No. 10/12 with twelve spindles suitable for 9½″ diameter chucks, ten vertical turning stations and eight horizontal facing stations. Electro-hydraulics are used on all No. 10 models for operating the chucks, engaging and disengaging the spindle drive clutches, and for the locating and clamping of the spindle carrier. The drive is by a 60 h. p. motor.

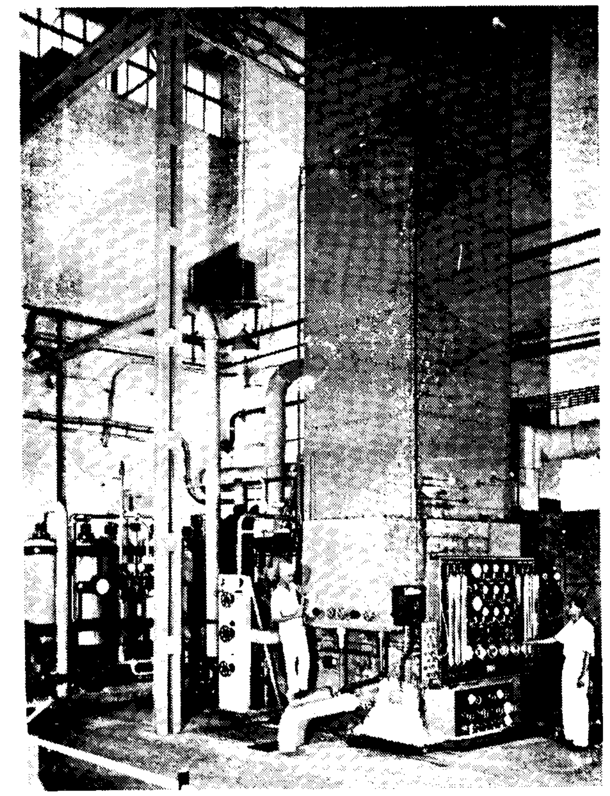
Many of the leading engineering companies in Great Britain and abroad are using Ryder automatics to speed output and cut costs, especially in the fields of automobile, locomotive, and domestic appliance production.

Nitrogen ; Oxygen boils at—183°C and Nitrogen at—196°C. If a mixture of the two liquid gases is liquid air is allowed to evaporate. Nitrogen will pass off more rapidly than the Oxygen, producing a concentration of oxygen in the remaining liquid. Another basic principle is that there is a definite relation between the compositions of liquid and gaseous phases of the Nitrogen-Oxygen mixtures and it is found that the vapours from the liquid mixtures always contain more Nitrogen and less Oxygen than the liquid. For instance, at one atmosphere absolute pressure the gas above the liquid air (consisting of about 21% Oxygen and 79% Nitrogen) will have a composition of 7% Oxygen and 93% Nitrogen. Unless this relation is satisfied, the liquid or gaseous phases cannot be in equilibrium. If the vapour has too high a percentage of Oxygen, the excess Oxygen will tend to re-liquify.

In the fractionating column of an Oxygen plant, liquid formed in the plant is vapourised and the rising vapours are brought into intimate contact with the falling liquid acting as a scrubbing agent. The rising vapours encounter liquids having a lower temperature and differing in composition from the liquids with which they would be in equilibrium. The vapours are warmer and richer in Oxygen than the equilibrium conditions required. Oxygen vapours are, therefore, progressively liquified and Nitrogen liquid evaporated in an effort to attain equilibrium with the net result that nearly pure Oxygen collects at the bottom, whilst vapour very rich in Nitrogen passes to the top.

In order to scrub out most of the Oxygen from the air treated, the rectification is carried out in two stages, i. e. in two separate rectification columns, one surmounting the other. The lower column pressure is in practice, greater than the pressure in the upper column by an amount greater than the vapour pressure difference between Oxygen and Nitrogen, so that it may be possible to condense Nitrogen at the top of the lower column with the aid of liquid oxygen boiling in the upper column.

Liquid and gaseous Oxygen can be produced in double rectification columns. To produce Oxygen in gaseous form air is required to be compressed to about 35 atms. while for liquid Oxygen production this initial pressure of compressed air is required to be between 150 to 200 atms. Over the last two decades, liquid Oxygen plants have been perfected to meet the need of the new method of transporting and storing Oxygen. Hitherto, this had been done mainly in the gaseous form in the well-known steel cylinders, at a pressure of about 2,000 lbs/sq. in., only a very small amount being conveyed in the liquid form. Oxygen can be more economically stored and handled as liquid than as gas and the problem involved is of maintaining a temperature lower than—183°C, above



The 400 M³ Oxygen Plant of Indian Oxygen Limited at Calcutta

which it would evaporate. Transport too, is facilitated with Oxygen in liquid form. One cubic foot of liquid Oxygen is approximately equivalent to 830 cu ft. of gas. A modern 7½ ton liquid Oxygen tanker, for example, can convey a load of liquid Oxygen which if transported in equivalent volume of compressed gas in cylinders would require nine such vehicles.

Liquid Oxygen is supplied primarily to those users who take the gas in sufficiently large quantities to prohibit its carriage in cylinders and these include small steel makers, who employ Oxygen for refining steel and treating the metals during rolling processes. At the consumers' works a liquid installation is provided from which the liquid is evaporated into gaseous form and piped to various points of consumption.

There are still many cases in which it is more convenient to use cylinders and on outdoor sites and in small factories these continue to provide an important service.

The use of Oxygen in large scale steel production is a comparatively new technique and now-a-days large volumes of Oxygen are used by the steel makers for reducing the refining time and increasing production rate. It was apparent that conventional liquid/gaseous Oxygen plants designed to meet the more modest general demand in industry would not meet these particular requirements. So a new type of plant called " Tonnage Plant " was developed to give large quantities of Oxygen gas at an economic cost for steel processing. Plants have been built to give 50,100 and 200 tons of Oxygen per day. The immensity of the problem strikes us forcibly when we consider that 200 tons represents over 5,000,000 cu. ft.

Basically the tonnage plants also employ the same principle of extraction of Oxygen from atmospheric air by compressing, pre-cooling, expansion, liquefaction and fractional distillation ; but Oxygen has to be produced at a much lower cost than by the conventional method. The development of these plants is based on the 'Lachmann's' theory that the requirements of fractional separation of air are such that only part of the air need be compressed to a high pressure and expanded. The rest of the air can be compressed to a moderate pressure, cooled by heat exchange to a low temperature and directly introduced into the fractionating plant.

In Oxygen production, the principal expenditure is power necessary to compress air before expansion. Introduction of Frankl Regenerators because of the low pressure drop made it possible to use two streams of air at low and medium pressures of 2 atms and 4 atms respectively as against 35 atms required for the conventional gas plants. These regenerators utilize the well-known principle of exchanging heat between gas streams by alternately heating and cooling solids packed in a tower through passage first of one gas and then the other through the packing. A further advantage of these regenerators is that these precipitate water vapours and carbon-di-oxide on the packing surfaces, which is blown out in the following cycle, thus obviating the necessity of carbon-di-oxide removal or moisture absorptions of air processed.

The main items of a tonnage plant are large centrifugal air compressors, turbo-expanders, coolers, regenerators and separating columns.

Most of the modern steel works are equipped with direct Oxygen supply pipeline from an Oxygen producing works. The earlier practice was to use atmospheric air and high nitrogen contents in air increased the energy required with a resulting decrease in efficiency of the process. Another vital problem that has been solved by substitution of Oxygen for air is the use of poor quality of ore and acute shortage of steel scrap making refining with air a much more difficult task. Removal of silicon from the blast furnace iron decreases refining time considerably. This de-siliconization is achieved by blowing Oxygen into the ladles containing molten metal. Production from the blast furnaces has been considerably increased by the use of Oxygen for blast enrichment. Saving in charging time of Open Hearth Furnaces is another example of the advantageous uses of Oxygen in the Steel industry. Oxygen assisted melting and refining has made it possible to reduce upto 20% of the normal melting time.

Besides steel making, there are very few industries where Oxygen is not used for one purpose or another. While Oxygen helps in achieving temperatures as high as 1600°C in blast furnaces, liquid Oxygen at—183°C is used by research laboratories for liquefaction of rare gases. Crews flying at an altitude of 40,000 ft. use pure Oxygen for sustaining while down below the surface of sea Oxygen is used for underwater cutting and salvage work. Large steel structures are fabricated by the use of Oxy-Acetylene torch and the same Oxygen in liquid form is used for blasting large rocks into small fragments.

Use of liquid Oxygen with a fuel as propellant of rockets is one of the latest applications of Oxygen. Use of Oxygen in the medical world is well-known.

As Industries progress, the use of Oxygen continues to offer a solution to many problems. Oxygen may be aptly called the barometer for the industrial progress of any country and it is difficult to forecast where the use of Oxygen will end.

ULTRASONICS AND THE RAILWAYS

By N. Ramanathan
Sales Engineer, Toshniwal Bros. Private Limited, Bombay-1

"ULTRASONICS" plays an ever-increasing part in non-destructive testing, and solves many a testing problem otherwise defying solution. We propose to consider here a few of the Ultrasonic testing methods used in non-destructive material testing, especially in relation to railway work.

The term, " ULTRASONICS " refers to vibrations and waves at frequencies exceeding the range of frequencies of the audible, sound spectrum. A certain amount of confusion exists between " SUPERSONIC " and " ULTRASONIC ", and we shall first of all make a distinction in the nomenclature.

Supersonic is used to refer to velocities exceeding the velocity of sound in a medium. Ultrasonic refers to frequencies higher than those audible to the human ear ; generally above 20,000 cycles per second, and extending upto a few megacycles.

THE ADVANTAGES OF ULTRASONIC METHODS

Radiographic methods, familiarly known as " Industrial X-rays " have been used over a number of years to determine the internal condition of materials and to detect flaws by non-destructive methods. While the X-rays have their use in certain fields, ultrasonic methods are free from several inherent disadvantages of the X-ray method.

1. Freedom from high voltage hazard.
2. Freedom from radiation hazard.
3. Ultrasonic methods normally require access only to one side of the piece under test, since the " Pulse-echo " method is generally used.
4. Ultrasonic testing equipment is more easy to handle, and generally lighter in weight. The main equipment can be remote-located, and only a probe, about 25 mm. in diameter is required to come in contact with the test object.
5. Immediate assessment of test results is possible, without the inherent delay in processing a film. A photographic record is not part of the process, but one can be provided when desired.

The third advantage, viz. the ability to work with access to only one surface is very important, as it makes possible the convenient inspection of boilers, axles ' in-situ ', pressure vessels or pipes with their contents, etc.

In practical ultrasonic testing, electronic high frequency oscillators and cathode-ray oscillographs form important components. They are built into compact easily transportable instruments, and supplied with the " probes " or electromechanical transducers, which actually help transmit the energy into the test piece.

A high frequency current generated by an electronic oscillator, usually pulsed about 150 times per second is applied to the probe which is in contact with the surface of the test body. The probe vibrates at the same frequency and irradiates the energy into the body. The behaviour of the ultrasonic energy inside the body enables the interpretation of its condition.

The entire process of ultrasonic flaw detection makes use of the property of ultrasonic energy being reflected at the interface between two adjacent surfaces. Hence, to push the energy into the body from the vibrating transducer, a couplant (grease or oil) is necessary as otherwise the energy will be reflected by the very thin air layer in between. The energy entering the object passes straight to the opposite surface if there is no break in the homogeneity of the medium. If there is a defect on its way, an inclusion, or a break or any other flaw, part of the energy is reflected back to the front surface, as an echo, and part transmitted onwards.

ULTRASONIC NON-DESTRUCTIVE TESTING

Three different techniques are generally applied in Ultrasonic non-destructive material testing :—

(a) Pulse-echo method.
(b) Through transmission method.
(c) Immersion testing technique.

Pulse-echo method or reflection method is by far the most commonly employed as it requires access only to one surface and the use of a single probe which acts alternately as the transmitter and the receiver. Short ultrasonic pulses of a frequency determined by the nature of the material of the test object are transmitted at regular intervals (e. g. 150 per sec.), from a soundhead or probe into the test piece. These pulses are reflected by the boundaries of the material or the flaws and after a few microseconds they reach the probe again, which then, acting as a receiver, transforms the reflected mechanical pulses into electrical pulses. This process is repeated some 150 times in a second, so that the Cathode Ray tube used to visualise the pulses shows a stationary image of the whole cycle of events. Fig. 1 illustrates the method and the trace on the screen of the cathode ray tube.

In the through transmission method of testing, two probes are necessary, one as the transmitter and the other as the receiver of the ultrasonic energy. The second probe is applied on the surface opposite to that by which the ultrasonic energy enters the test object and is used to detect the energy that has travelled through. Any intervening flaw is indicated by the attenuation of the energy, resulting in a smaller 'Pip' or pulse on the cathode ray tube.

While it is possible also to measure the distance of the flaw from the surface by interpreting the travel time in the case of the pulse-echo method, this advantage is not available in the through transmission method. Immersion testing technique is employed under special conditions where other methods are difficult or impossible and especially in the case of complicated shapse where it is difficult to apply a probe to the surface and get good contact. The test object and the probe or probes are immersed in a liquid medium, such as water or oil. This method achieves particularly constant coupling conditions, great testing speeds, and the transducer crystal does not undergo the wear and tear resulting from frequent and repeated direct contact. Both singleprobe pulse-echo and through transmission double probe methods

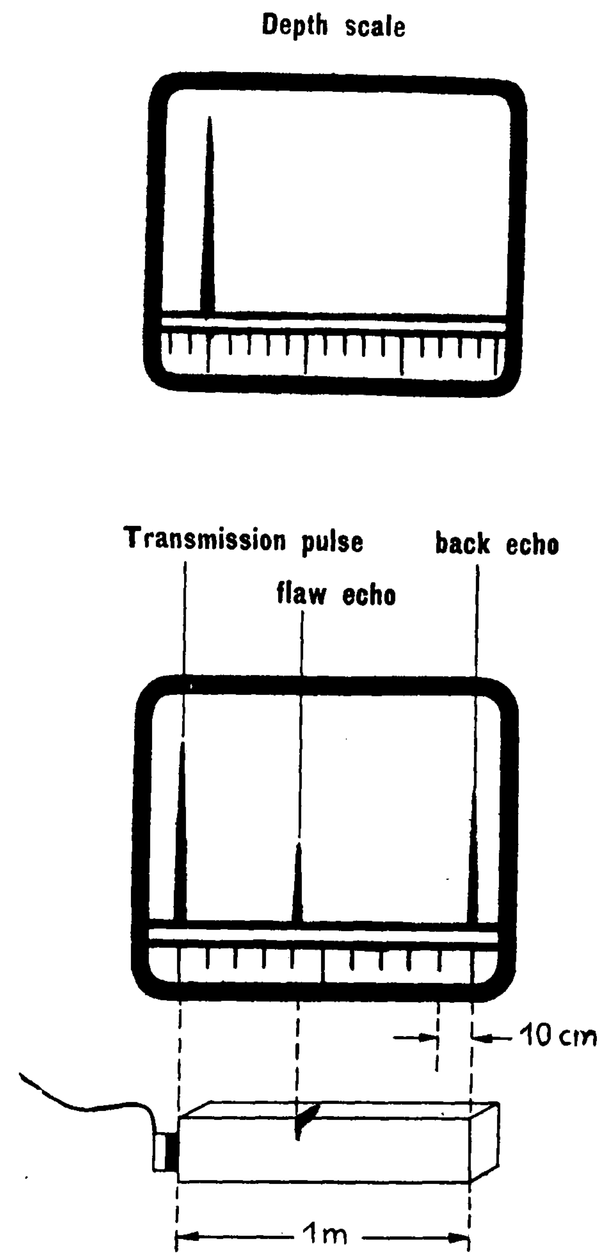


Fig. 1. Pulse–echo method showing depth scale.

are adaptable to the immersion technique. Fig. 2. illustrates.

ULTRASONICS AND THE RAILWAYS

Indian Railways have been quick to realise the advantages of Ultrasonic testing and several Flaw Detectors are in use, by the different zonal units. More units are in the process of being acquired.

Ultrasonic methods are especially suited to the inspection of railway wheels, axles, boilers, rails on the permanent way etc.

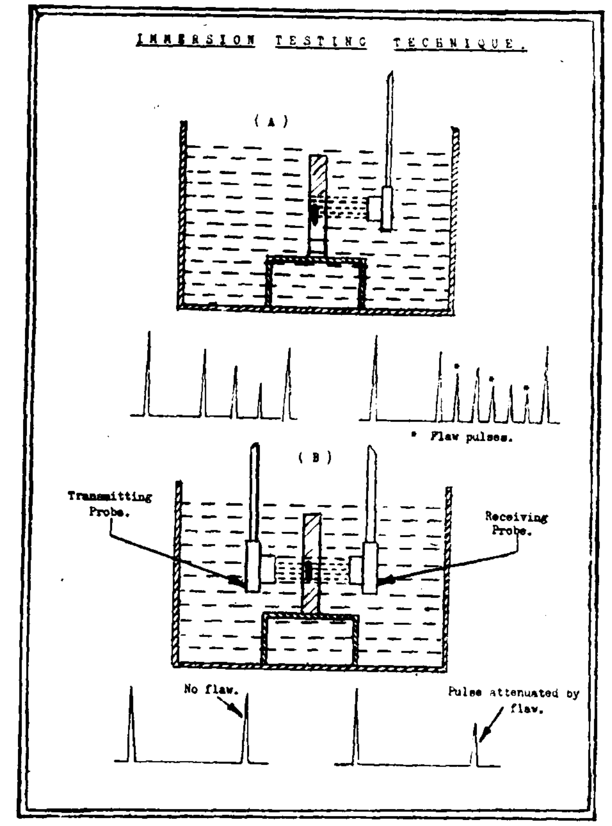


Fig. 2. Immersion testing technique showing, (A) Single Probe and (B) Double probe methods, and typical traces on Cathode Ray Screen

Axles can be tested without removal from the locomotives. A combination of tests with straight and angle probes will reveal flaws in any part of the axle. Remote corners and areas not covered by straight (longitudinal) or diametral irradiation are accessible to beams irradiated at an angle by the use of angle probes. Please see fig. 3. It is possible thus to detect cracks or flaws in railway axles not revealed by other testing methods.

Ultrasonics are also used to determine the fatigue cracks originating from shatter cracks or flakes in the rims of railroad wheels.

Boiler plate and weld testing are made easy by ultrasonic flaw detectors. Besides using the instruments to inspect the welds, and the boiler plates themselves, for flaws, it is possible to determine the accumulation of scale.

The rails on the permanent way are most easily checked with lightweight, portable, ultrasonic testers, or completely equipped automatic test detector cars which traverse the track to be inspected, covering long lengths of track in a short time.

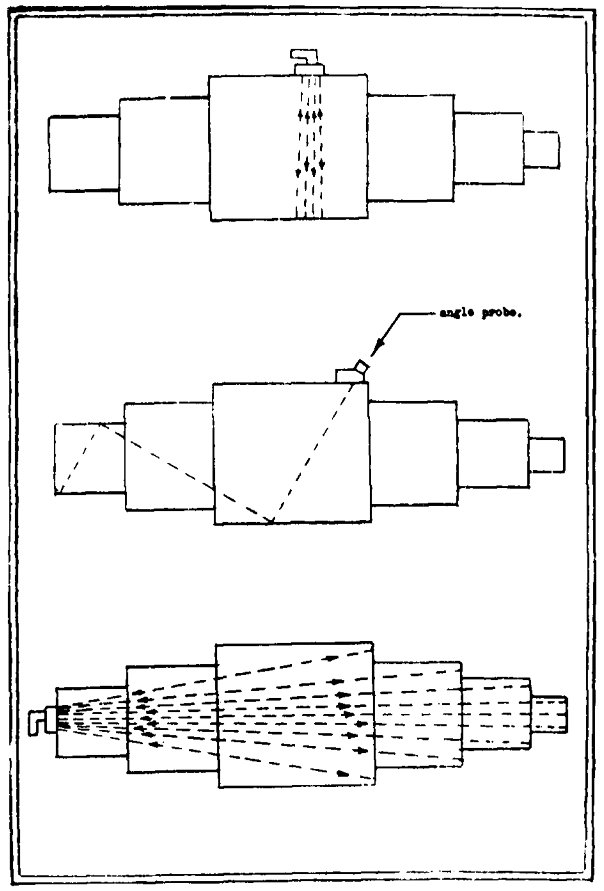


Fig. 3. Axle testing, by longitudinal, diametral and angular irradiation.

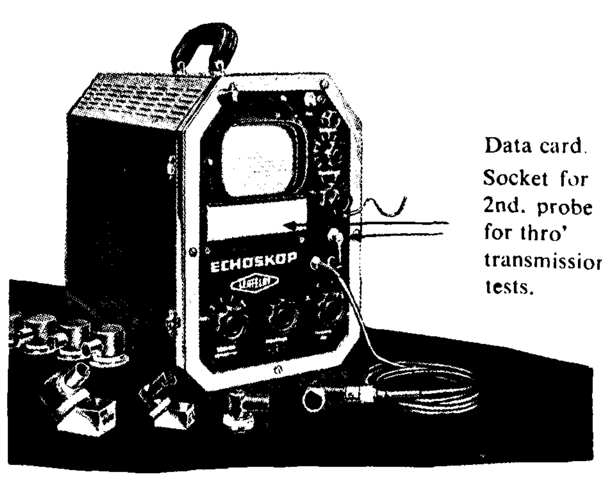


Fig. 4. The LEHFELDT ECHOSKOP model MPR-5, which delivers four ultrasonic frequencies and has a built-in electronic depth scale traced on the screen beneath the main trace. Note the wide variety of probes. The data card is for recording test data for photographing, with the screen trace.

STANDARD EQUIPMENTS

Dr. Lehfeldt & Co., Germany, market three models of Ultrasonic flaw detectors under the brand name of ECHOSKOP. A single frequency model is available for limited applications, requiring only one testing frequency, and sufficient for most testing work relating to limited ranges of materials. The ECHOSKOP model MPR—5, fig. 4, delivers four ultrasonic frequencies, and is highly versatile, suitable for many varied testing problems. A six-frequency model, the MPR—105 is also available. Lehfeldt also offer a very wide range of probes, such as standard probes for regular work, protected probes for use on rough surfaces, angle probes for checking welded joints and other special work, and a very special variable angle probe, which enables rapid testing of thin sheets, by the use of LAMB waves. Underwater probes for immersion tests are also available. The MPR-5 and the MPR 105 also have a built-in electronic depth

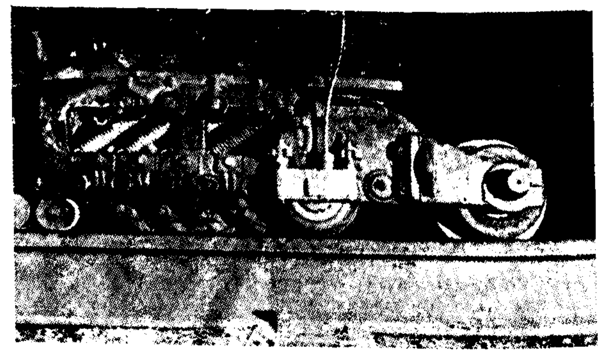


Fig. 5. SPERRY ultrasonic transducer wheel mounted on brush carriage.

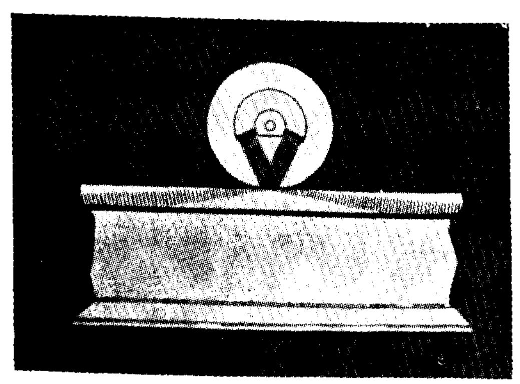


Fig. 5a. Method of projecting ultrasound into the railhead. Two 2.25 Mc/s crystals set at a test angle of 70° and mounted within the liquid-filled transducer wheel.

scale traced on the cathode ray screen beneath the main trace, enabling direct reading of the distance of a flaw from the surface. An automatic flaw alarm, the ECHOMAT is available against request. The ECHOSKOPS are also suitable for wall-thickness measurements.

Fig. 5 shows a SPERRY ultrasonic transducer wheel mounted on brush carriage of a detector car for locating transverse defects along entire lengths of track. The method of projecting ultrasound into the rail head is shown in fig. 5a. Two 2.25 Mc/s crystals are mounted at an angle of 70° within a liquid-filled transducer wheel.

Of very special interest to permanent way engineers of Indian railways will be the DAWE AUDIGAUGE ultrasonic rail flaw detector of fig. 6, consisting of a lightweight, portable instrument, with a long-handled search unit for the detection of cracks and other defects in rails and rail joints. The unit operates at a frequency of 3.5 Mc/s and weighs only 11 lbs. In

Fig. 6. The DAWE AUDIGAUGE, ultrasonic rail flaw detector, for detecting cracks and other defects in rails and rail joints. The transistorised model gives both visible and audible indication. Weight 5 lbs.

these days of transistor radios, and transistorised everything, the reader will be wondering if a transistorised flaw detector cannot be made available. YES, the DAWE Audigauge is also made in a fully transistorised model weighing only 5 lbs ; both types operate from self-contained dry batteries.

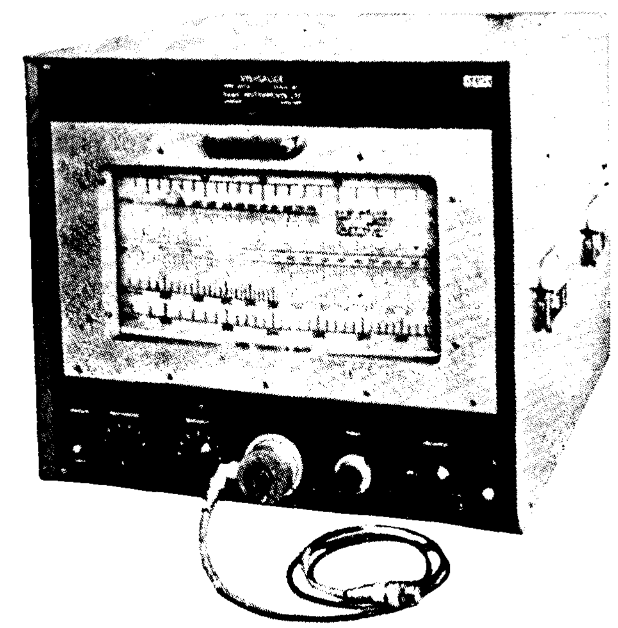


Fig. 7. The Dawe VISIGAUGE, Ultrasonic thickness gauge.
Thickness range : from 0.005" to 2.5", direct reading

Dawe Instruments also offer an ultrasonic thickness gauge, fig. 7, suitable for production testing with laboratory accuracy and versatility. It measures thickness from one side and gives an instantaneous direct reading, and can be used with extension transducer cables upto 1000 ft, long. The DAWE VISIGAUGE is suitable for objects with flat, cylindrical or spherical surfaces.

Other applications of ultrasonics will be of general interest to the reader, and include medical instruments, blind-guidance devices, cleaning equipments to penetrate effectively inaccessible crevices and cavities, as in the case of hypodermic syringes and needles, soldering and brazing, dental cutting, drilling of fragile objects, charting of depths, burglar alarms, rapid fish-location, and even for checking livestock.

Fuller details of any of the instruments referred to herein can be had from Messrs. TOSHNIWAL BROTHERS PRIVATE LIMITED, 198, Jamshedji Tata Road, Bombay-1.

SILICON RECTIFIERS FOR ROLLING STOCK

By An Engineering Correspondent

INTRODUCTION

MERCURY rectifiers were used at first as rectifiers for A. C. electrification of rolling stock. Hitachi produced 2,046 kW excitron type rectifiers for a total of 42 cars, but since 1958 it has adopted a policy of promoting the use of silicon rectifiers as a railway power source. It is firmly believed that silicon rectifiers not only have the advantages listed below over mercury rectifiers, but they are also in no way inferior to mercury rectifiers in both reliability and in length of service life. For this reason, ever since 1961, all of the rectifiers for A. C. electrification manufactured by Hitachi have been exclusively silicon rectifiers.

The following advantages of silicon rectifiers can be mentioned :

(1) They are light in weight and small in dimensions.

(2) They are simple in construction, have few accessories, and are easy to handle and operate.

(3) They need no temperature control and can start up in a very short time.

(4) They have good vibration resistance.

(5) They have a high efficiency.

Because of these advantages, they are extremely suitable for use in rolling stock.

RECTIFIER CELLS

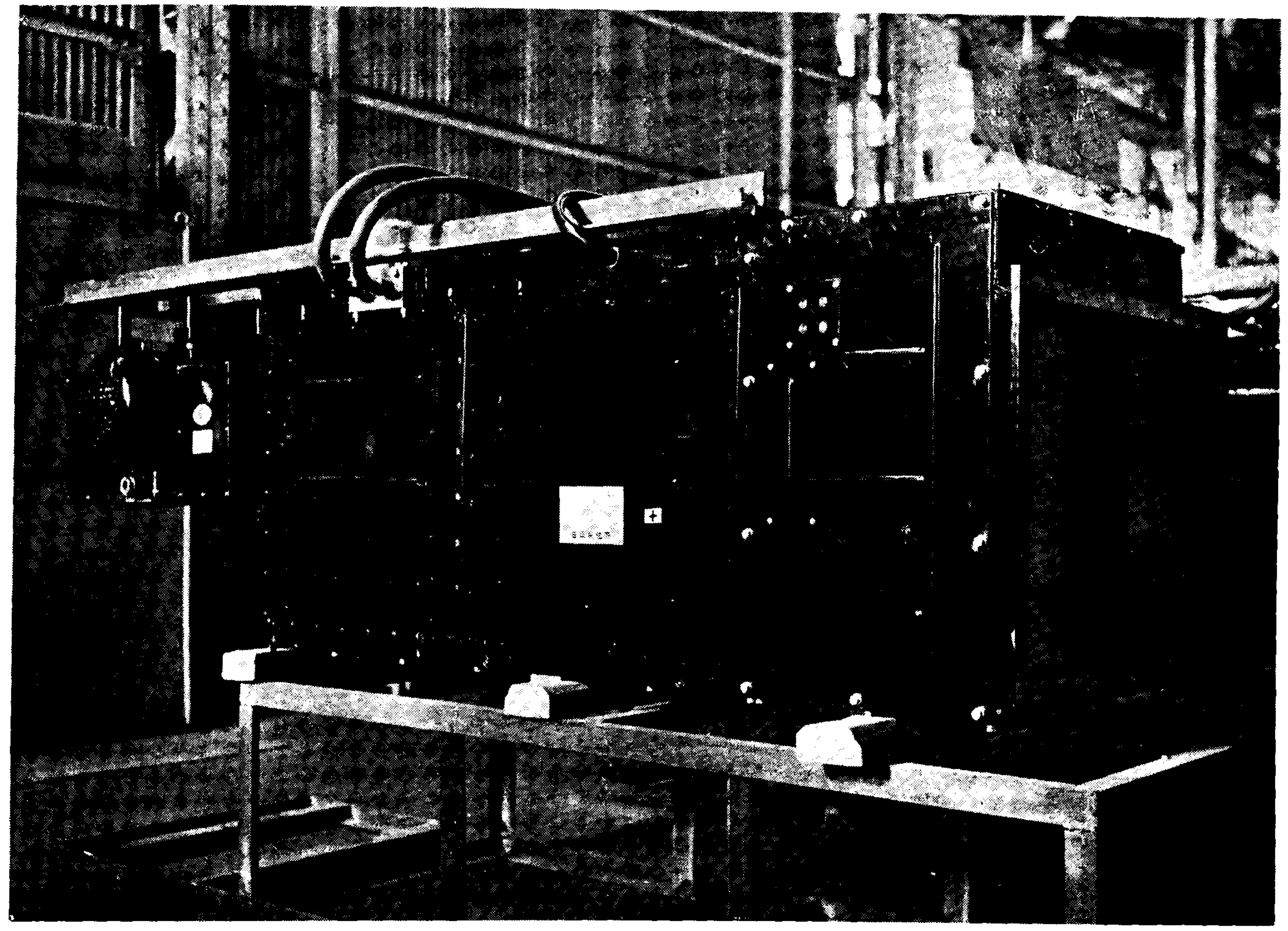
The silicon rectifier cells used in Hitachi silicon rectifiers are produced in bulk quantities under conditions of the superior production techniques and rigid quality control for which Hitachi is justly famous. Single crystals of particularly high purity and large diameters are used. The P-N junctions are produced by the diffusion process, a process developed at Hitachi. This process reduces the impurities in the junction to a low concentration, and the junction is given uniform characteristics. Cells have been manufactured with a maximum current capacity per cell of as high as 500A, but from the economical viewpoint, cells with an average forward current of 200A and a P. I. voltage of 1,000—1,500V are manufactured in the largest numbers. Silicon rectifier cells for rolling stock use are required to have a construction able to withstand intermittent loads and to have great strength against vibrations. Hitachi standard cells meet all of these requirements perfectly. The soldering materials and the soldering process of Hitachi silicon rectifier cells have been developed as the result of extensive study, so that the construction is highly able to withstand intermittent loads; they have successfully passed type tests including intermittent load tests of up to hundreds of thousands of cycles. A ceramic seal, which has great mechanical strength, has been adopted as the hermetic seal, and this seal has passed with flying colors shock tests of 1,000 g, as well as 5—50 cycle, 1 g vibration tests.

PROTECTIVE DEVICES

It is desirable for all rolling stock machinery to be as simply constructed and as highly reliable as possible. The protective devices of the rectifiers have also been planned along these lines, incorporating special features to fit the actual conditions in rolling stock operation.

VOLTAGE

Since the silicon rectifier cell itself has essentially a small impulse ratio, care must be exercised regarding surge voltage. In rectifiers for railway service, a special problem is presented by the switching surge on the high voltage side air blast breaker. To cope with this, a surge absorber is provided, besides which a non-linear resistance is installed parallel with the air blast breaker. Also, an arrester is installed on the air blast breaker's load side. All of these measures combine to produce a significant decrease in the surge voltage. On the silicon rectifier side, the number of cell series has been selected in accordance with these conditions in order to provide a well balanced, harmonious arrangement. For improving the voltage distribution in the cells, a capacitor and a resistance



have been provided parallel with the cells; this arrangement suppresses the imbalance of the voltage distribution in most cases to ±10. In case one cell should become deteriorated, a deterioration detector device has been provided which detects and indicates any such deterioration; but there is always one spare cell connected in series so that the train can continue to travel even during this interval.

CURRENT

The number of cells in parallel connection is determined by the amount of overload occurring when the train starts on a grade. The current conditions are given adequate study, and in cases when this number of cells is sufficient in itself, no additional protective devices except the high speed relay and the air blast breaker are provided. It would not be advisable, in view of the weight and dimensions, to make special provision of a current balancer for the sake of current distribution. Therefore, the forward voltage drop is kept balanced within a certain range, and the imbalance in current distribution is kept suppressed usually to about ±10—15%. Of course, ample considerations have been paid to current imbalance due to wiring impedance.

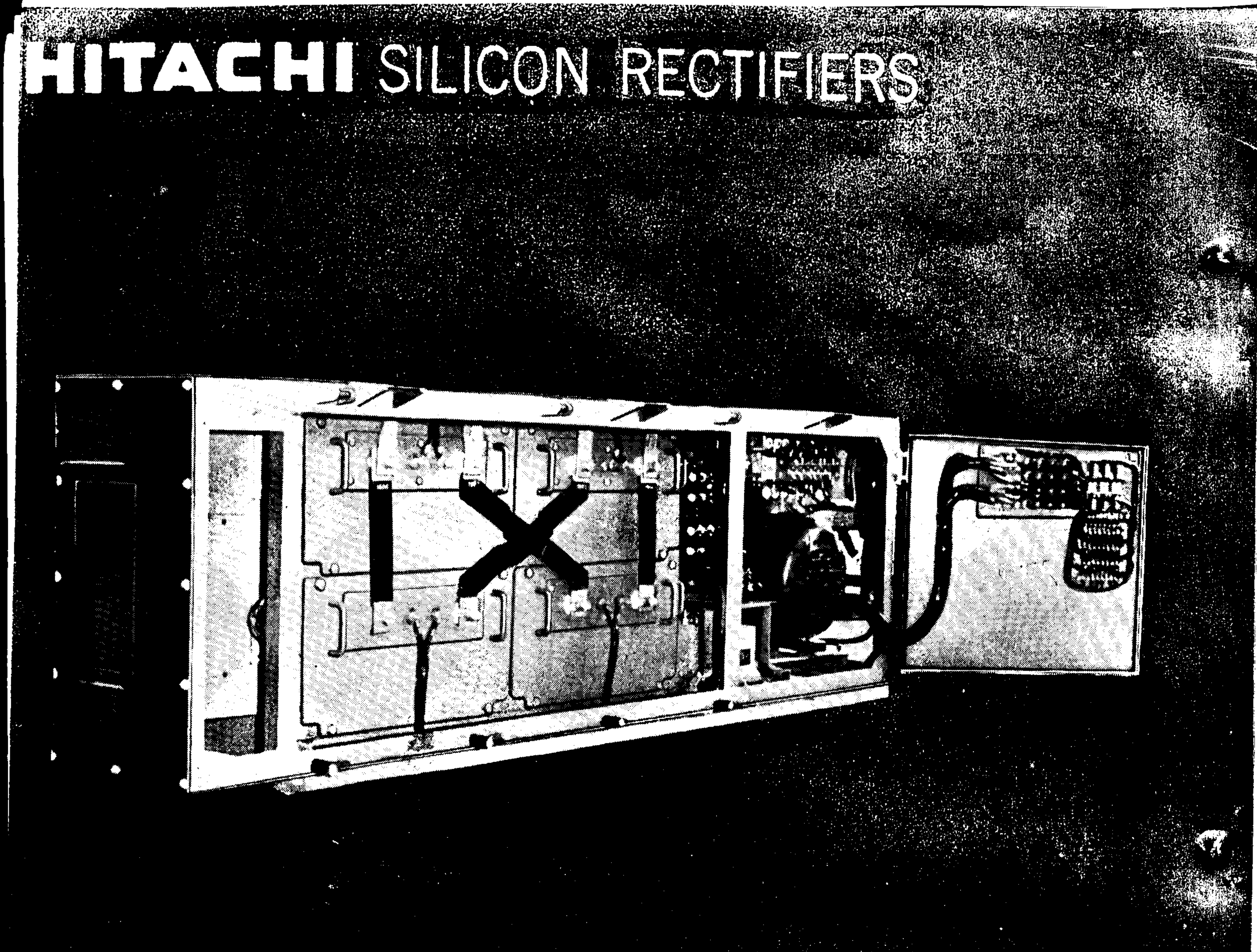
REPRESENTATIVE PRODUCTS

Hitachi, Ltd., is the manufacturing company with the most abundant experience in the production of rectifiers for A. C. electrification for the Japanese National Railways. Especially with regard to silicon rectifiers, it is now supplying about 85% of those for locomotive use, and about 40% of those for electric cars. The total production to date amounts to 86, with a total output of 140,000 kW, including those now in production. In the following we introduce a few representative examples of Hitachi products in this line.

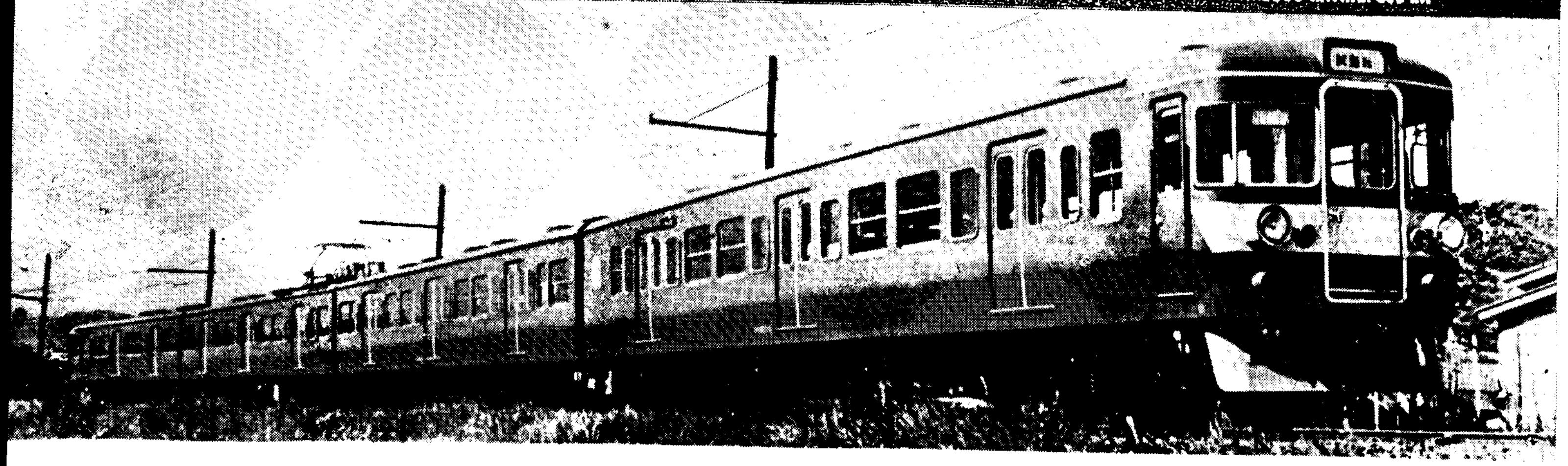
SILICON RECTIFIERS FOR SERIES 401 ELECTRIC CARS

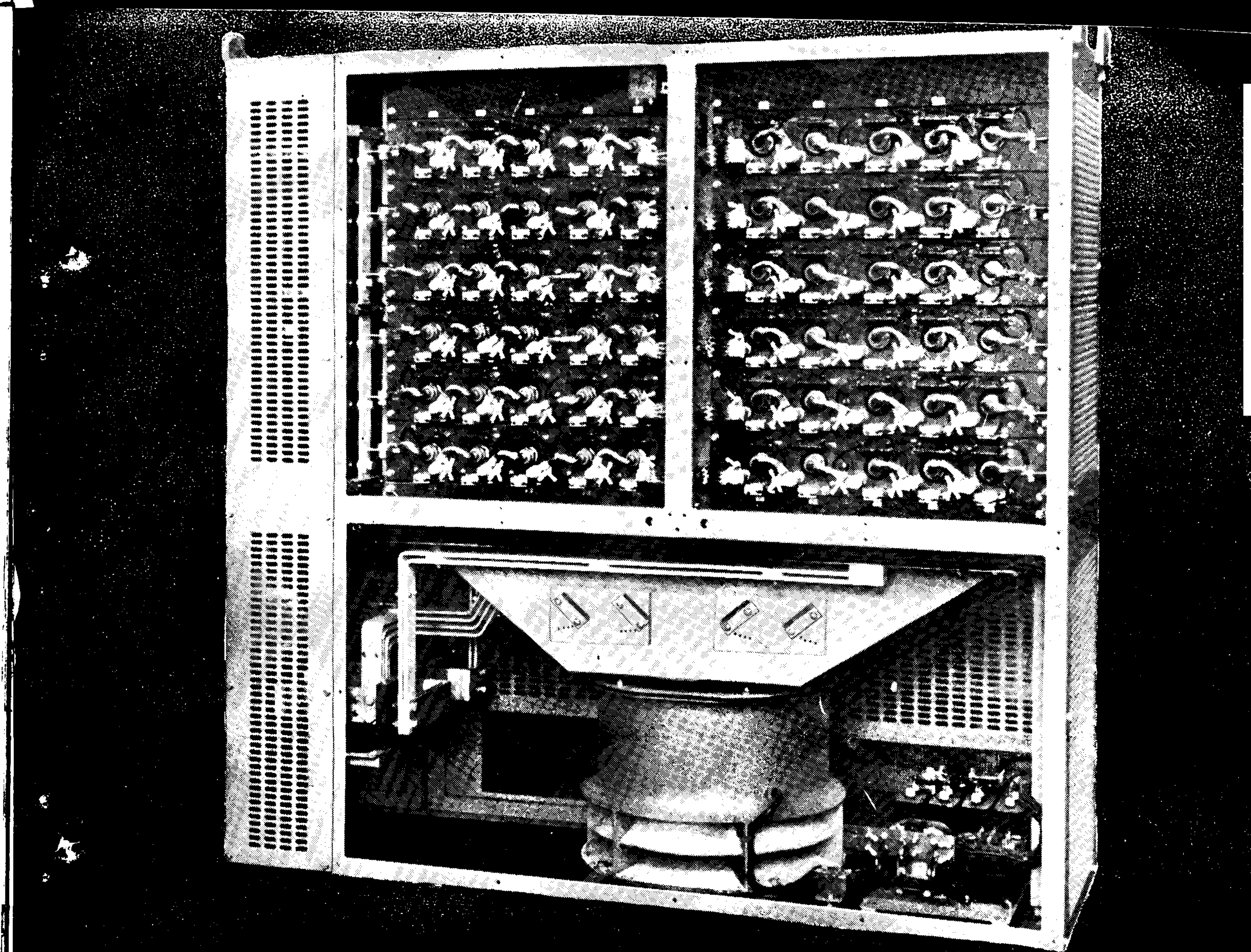
These are used in AC-DC dual-system electric cars

HITACHI SILICON RECTIFIERS

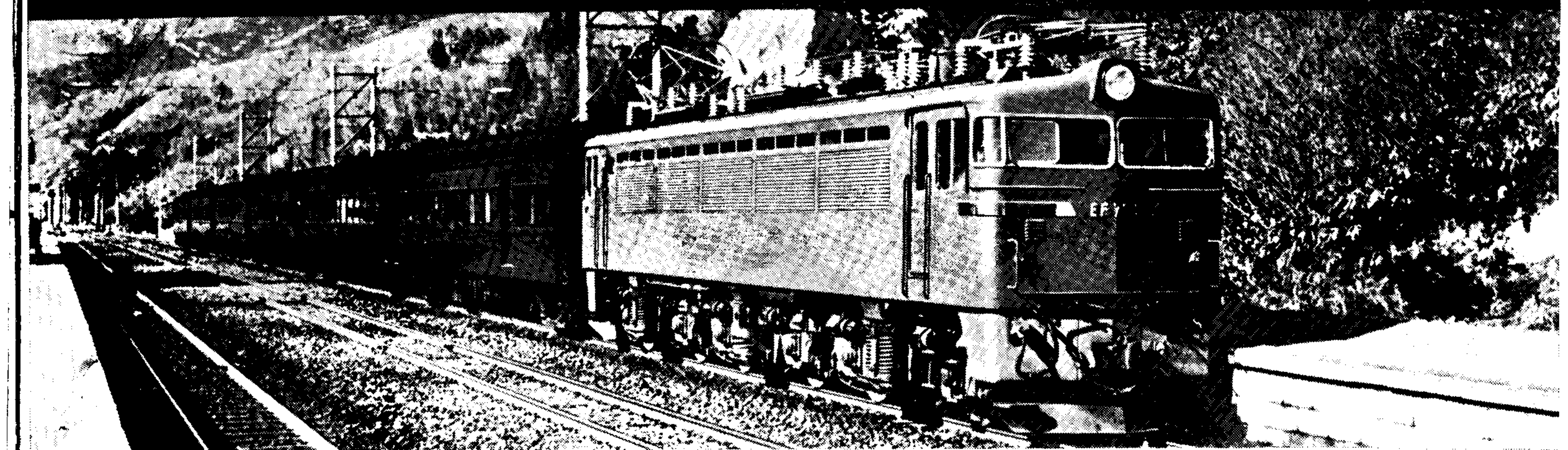


SILICON RECTIFIER SET FOR SERIES 401, AC-DC DUAL SYSTEM COACHES —CONTINUOUS RATING: 810 kW





SILICON RECTIFIER SET FOR TYPE EF70 AC LOCOMOTIVES CONTINUOUS RATING: 2340 kW



Flawless performance demonstrated by Hitachi silicon rectifier system

Hitachi silicon rectifier sets for electric locomo-
es and 36 sets for electric coaches have been
pplied to or are now being manufactured for the
panese National Railways. Those already delivered
ve demonstrated their technical superiority in actual performance. Ratings of the sets for locomotives range from 1500 kW to 2500 kW, for a total of 110,000 kW. Those for coaches range from 600 kW to 1500 kW, for a total of 29,000 kW.

Some of the advantages of the Hitachi silicon re- ctifier system are its high efficiency, simple construction, reduced size, and light weight. Because the sets are manufactured in their entirety—from simplest element to assembled unit—by Hitachi, their characteristics can be guaranteed. Hitachi's mass production facilities insure uniform quality and quick delivery. Descriptive literature available on request.

Hitachi, Ltd.
Tokyo Japan Cables: "HITACHY TOKYO"

for commuter service on the Joban Line, and are the first mass-produced silicon rectifiers for rolling stock use ever produced in Japan. The rectifier cells have PIV of 700V and 200A. 80 cells are used in each rectifier, and the rating is 810 kW/1,350V. The rectifier is installed under the floor of the car. Twelve of these rectifiers have been produced so far, and an additional five are now in the process of production. An additional seventeen rectifiers of identical capacity are also being produced for use in the Series 451 express trains of the Joban and Tohoku Lines. In these rectifiers, cells with PIV of 1,000V and 200A are used, and the number of cells has been reduced to 64.

SILICON RECTIFIERS FOR THE TYPE EF-70 LOCOMOTIVES

These are for use in locomotives for freight trains on the Hokuriku Line and are the largest silicon rectifiers in Japan for rolling stock use. The cells have PIV of 1,000V and 200A, and 240 cells are used in one rectifier. Eighteen of these rectifiers, which have a rating of 2,430kW/750V, have been produced.

SILICON RECTIFIERS FOR TYPE EF-80 LOCOMOTIVES

These are for use in 2,200 kW 1,500V AC-DC dual-system locomotives on the Joban Line. The cells, which have PIV of 1,000V and 200A, total 252 in each rectifier. In addition, they also contain silicon rectifiers for reverse current prevention in separately excited motors, such as the motor-generator for the heating system. Thirty of these rectifiers are now in production.

Besides those mentioned above, another noteworthy product is the silicon rectifier produced for installation in the prototype car for the New Tokaido Trunk Line. This rectifier is installed under the car floor, but lamp indication is performed inside the car should a fault occur in the rectifier.

Each and every silicon rectifier put into commercial operation so far has chalked up an excellent record in actual operation, providing convincing proof of the superiority of silicon rectifiers for railway service and of their great reliability.

Chittaranjan Locomotive Works Supplement

Electric Locomotives are now Made in Chittaranjan

By G. P. Shahani
Formerly, General Manager, Chittaranjan Locomotive Works.

The author, until recently, the General Manager of the Chittaranjan Locomotive Works describes the first electric locomotive built in India, which was launched on the track by the Prime Minister at Chittaranjan in October last. Turning out 164 locomotives a year, the Chittaranjan Locomotive Works, has already made Indian Railways completely self-sufficient in Broad Gauge Steam locomotives.

ALTHOUGH the Indian Railways are about 109 years old, the Railways activities till Independence were mainly confined to "operation" and "maintenance". They relied mostly on imports to meet their requirements of stores and equipment.

It was only after 1947, when the country won her freedom, that the Railways took up seriously the question of self-sufficiency in the procurement of their rolling-stock, stores and equipment. Since then, and particularly during the two Plan periods, they have developed indigenous capacity in many directions and have been able to considerably cut down imports.

CHITTARANJAN SHOWS THE WAY

In 1948, the Indian Railways started work on a production unit of their own for the manufacture of steam locomotives at Chittaranjan in West Bengal. The first steam locomotive rolled out of the Works in November 1950. Confining itself only to the manufacture of Broad Gauge locomotives, mostly WG tvpe (the Indian Railways standard for the freight locomotive), it has turned out, up to the end of August, 1961, about 1,249 BG locomotives. Out of this, 1,239 are WGs and the remaining 10 WTs.

The WT Locomotives are designed for branch lines where they can haul both passenger and freight traffic. The WG locomotives are hauling heavy freight trains on the BG trunk routes all over India meeting the ever increasing demands from the new and expanded industries.

ELECTRIC LOCOS GAIN GROUND

Although the steam traction has held its ground and served us well over a century, it is evident that Indian Railways can no longer cope with the increasing traffic arising out of the rapid industrialisation of the country, by relying exclusively on steam locomotives. In fact the phenomenal spurt in the density of the traffic as well as the exacting requirements of present day railway operation have already necessitated the introduction of diesel and electric traction on some of the busy routes. Electric traction is indeed destined, even in India, to replace progressively steam traction.

Up to the end of the First Plan, only about 250 route miles near Bombay and Madras had 1,500 volts D.C. electric traction. Early during the Second Plan electric traction was brought for the first time to the Calcutta area—on the Howrah-Burdwan and Sheoraphulli-Tarakeswar sections—on 3,000 Volts D.C. system.

Later it was decided to adopt 25 KV, cycles, A.C. system for electric traction on Indian Railways because of greater economy and superior performance of the new system. During the Second Plan, considerable progress has been made on the A.C. electric traction on the Eastern and South-Eastern Railways in the coal, steel areas. About 600 route miles have already been brought under electric traction.

It is proposed to introduce electric traction on another about 100 route miles during the Third Plan. With the rapid expansion of electric traction, the demand for electric locomotives also increased considerably. Thus the need for manufacturing electric locomotives became apparent.

The Railway Board, therefore, intended to make a start in this direction by manufacturing a few D.C. Locomotives at Chittaranjan. It was decided to develop capacity at the Chittaranjan Locomotive Works for manufacturing six electric locomotives a month in addition to maintaining the present monthly rate of production of 14 BG WG steam locomotives.

While mechanical parts of the electric locos will be all fabricated at Chittaranjan, the electric equipment will, in the initial stages, be imported from abroad. Later, when the Heavy Electricals at Bhopal, develop capacity for the manufacture of electric equipment, the need for import from abroad will disappear.

INDIA-MADE ELECTRIC LOCO

The first electric locomotive, now ready to leave the Works is a 3,600 H.P., 1500 Volts D.C. The locomotive, has most of its mechanical parts completely manufactured at Chittaranjan. The electric equipment has been imported from U.K. It has got about 34,000 components of 3,900 different types.

Although this is the first venture of the works at Chittaranjan on the manufacture of electric locomotives, it speaks highly of their skill that very little of the work had to be rejected and redone. Some of the foreign experts maintained that that it would take at least 14 months to turn out the first electric locomotive. In spite of the delays and setbacks in receiving the electrical equipment from abroad, this first electric locomotive has been built by Indian workers at Chittranjan well within a period of 12 months only.

TECHNICAL FEATURES

The locomotive, which earns the proud privilege of being launched on track by the Prime Minister, will be assigned to the Central Railway. It can be utilised to haul both passenger as well as freight traffic on the difficult western ghat sections of that Railway. Having tractive efforts of 69,000 lbs. it can haul on the level an express train of 560 tons at a maximum speed of 65 M.P.H. or a goods train of 2,000 tons at a maximum speed of 45 M.P.H. It weighs 123 tons and has an axle load of 20.5 tons. It is mounted on the bogies, each with three axles. Each axle has been fitted with an independent traction motor to drive it.

These locomotives are equipped with the regenerative braking to keep the heavy trailing load under control on steep descending grades and thus reduce the heavy wear and tear on the tyres as well as the brake gear. The newly-built locomotive incorporates many safety devices to ensure its safe operation, such as overhead relay, no-current relay, current balance protection, low pressure governor, vacuum control governor, earth fault relay and lightning arrestor and surge absorber.

IMPRESSIVE PERFORMANCE

While the manufacture of electric locomotive adds another feather to its cap, the C.L.W. continues to march ahead in the matter of steam locomotives progressively improving its already impressive record of performance.

The prime cost of a steam locomotive which in the first year of production was over Rs. 7 lakhs, has now been brought down to Rs. 4.06 lakhs only. The number of man-hours per locomotive have also been reduced from 4,51,000 in the first year of production to only 54,000 now.

An incentive bonus scheme was started in the year 1954—55 and it now extends to all the production shops and a few of the service shops. By virtue of the scheme, not only has the production gone up, but also the workmen have increased the contents of their pay packets.

STEEL FOUNDRY

Besides developing the facilities for the manufacture of electric locomotives, Chittaranjan is planning to instal during the Third Plan a Steel Foundry at an estimated cost of Rs. 3.7 crores. It will have an initial capacity of 7,000 tons per annum, capable of expansion to 10,000 tons per annum. The foundry is scheduled to go into production in 1963.

Although galvanising has nothing to do with production of steam locomotives, a Galvanising Plant was erected at Chittaranjan in 1959 to assist the sister organisation the Railway Electrification Project. A total of about 10.000 tons of steel structures have been galvanised which has already resulted in a saving of about Rs. 40 lakhs in foreign exchange and of about Rs. 30 lakhs in the Capital estimate.

The workers at Chittaranjan are associated with the running of the shops and township through the Staff Council, Works Committee and Area Committees. They are encouraged to suggest ways and means to improve productivity and conditions of work. The staff concerned have been awarded with monetary rewards for suggestions accepted.

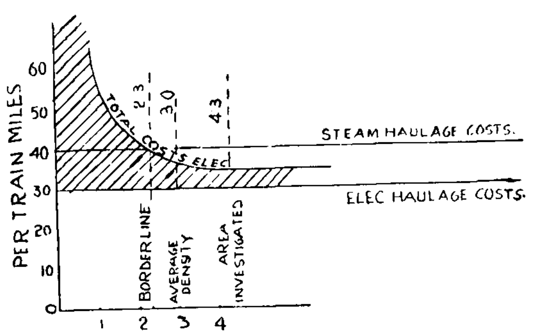
The total strength of employees is approximately 8,400. About 6,200 houses have been built for the employees of Chittaranjan locomotive works in a township covering nearly 7sq. miles. Some of the staff are drawn from the neighbouring villages. There are two high schools—one for boys and the other for girls—and 26 other primary schools, a 70-bed main hospital and four dispensaries in the township.

ELECTRIC LOCOMOTIVES

By Shri K. G. Belliappa
Dy. Chief Mechanical Engineer, Chittaranjan Locomotive Works

THE Indian Railways have ventured upon a large scale programme of Electrification. Our experience of operation by electric traction upto now has been limited to a length of about 280 miles of the 1500 Volt DC system started during 1925 in Bombay and later at Madras. It is for the Bombay area that we here in Chittaranjan have been called upon to build the first few locomotives, which will be followed by AC Locomotives of the continental group design.

The Second Five Year Plan was intended to electrify 1250 miles at a cost of Rs. 60 crores. The electrification of the Calcutta area is expected to give a return of 15% on the capital invested while 118 electric locos and 580 multiple units replace 580 steam locomotives and 1060 coaches. The economies of the programme are so evident when it is remembered that the Electric Locomotive as a tractor is about 3 times as efficient as its steam counterpart, besides having greater availability 93% against 80%, reduced maintenance costs, a reduction in operating staff, greater thermal efficiency 19% against 6%, higher acceleration, faster speeds and a greater power-weight ratio. Indicated below is a graph of the relative financial results of electrification recorded in Britain in 1957.



TRAFFIC DENSITY IN MILLION TRLG
TON MILES PER RUNNING TRACK MILE PER ANNUM

Much of the controversy between the different systems of traction between 1925 and 1955 outside India saw in the end a firm but significant advance of the high voltage single phase AC system to the recession of all others. The arguments of its advantages are not entirely without opponents, but it is evident that for the 25 KV AC system the sub-stations can be situated 30–50 miles apart as against 15—30 miles for the 3000 Volt DC system. The overhead conductors are thinner, the structures supporting them are less substantial than existing DC systems. As the traffic density increases, the demand for current increases tending to increase the line conductor size and supporting structures. Current technical advancement limits the size and horsepower of DC motors, which can be mounted on locomotives.

Traction motors, the most expensive items of electrical equipment, are mounted either on the bogies or underframes. The shocks in service undergone by these motors, which transmit their rotational movement to the wheels, call for careful designs of suspensions and transmissions. The 1500 Volt DC Loco has nose suspended motors mounted on bogies with fixed pinions, which mesh with gears fixed on the axles directly. All power fed to traction motors is DC. AC power, therefore, has to be rectified to DC before it is fed to the traction motors. Rectifiers are of the Ignitron, Excitron or Silicon types, the last named claiming the increasing attention of locomotive builders.

The basis of any control system in electric traction is to feed the motors with gradually increasing proportions of the line current to give adequate torque to start the loco, slowly accelerate it and finally maintain its road speed. On the DC Loco this is achieved by inserting banks of resistances, which are gradually cut out to suit the progress of the vehicle. On the AC locomotives tap chargers on the primary circuit of the transformers furnish this facility.

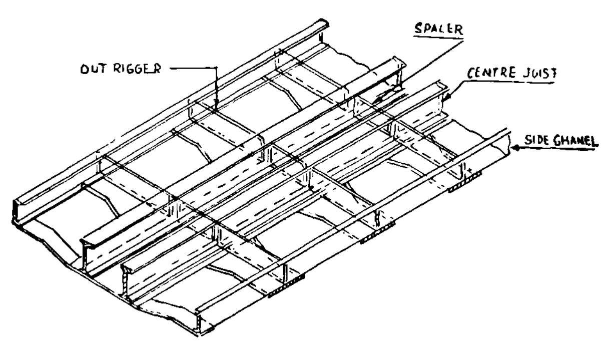
A large number of safety devices are introduced into the power and control systems to prevent damage to the equipment due to faults arising in operation ; such as *a no current relay* to accommodate any sudden break of supply from the overhead line ; *an over voltage relay* to limit the power fed back to the OHE from the regenerating system ; *a reverse current relay* to prevent the batteries from feeding back into the M.G. set ; *a current balance relay* to ensure that any fault in the system near the main supply from the pantograph does not adversely affect other equipment.

Regenerative equipment is provided on the DC locos as they have to work on heavily graded sections of considerable lengths. This gives good control over descending trains, saves wear on brake blocks and the power fed back to the overhead line results in considerable savings. The auxiliaries comprising of traction motor blower fans, compressors, pressurising fans, exhausters for vacuum brakes, motor generator for excitation during regeneration and operation of controls, besides batteries were some of the items essentially considered in the design of this locomotive, as will be in others.

It is, however, towards the harnessing of our production scheme for the construction of the locomotive that our major efforts have been directed so far. A few examples of the problems faced are illustrative of the scope of our endeavours.

THE UNDERFRAME

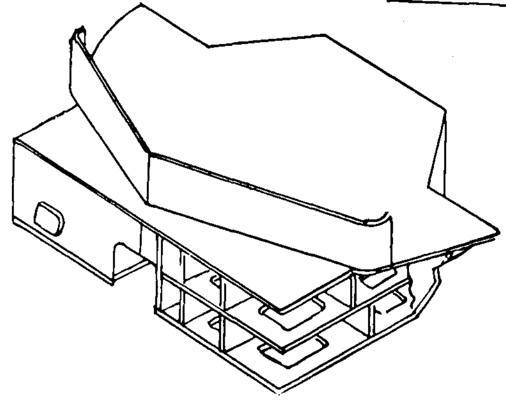
The skeleton frame work of the underframe and its end structures suffer all the strains of draft and buffing forces making it the most vulnerable assembly of the



UNDER FRAME.

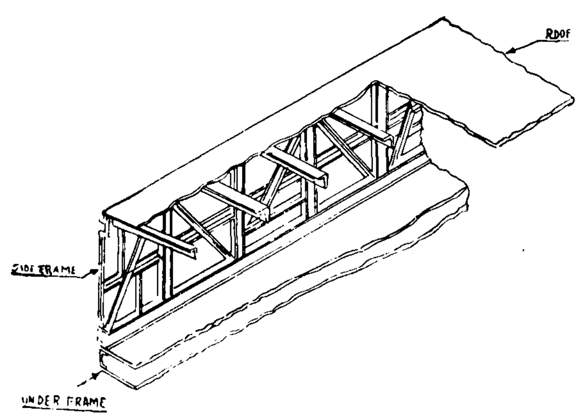
vehicular portion. A glance at the sketch gives an idea of the components, which go to make them up. Few will forget the idiosyncracies of the first one. Advice from sources outside our Administration was free and boundless but the birth pangs had to be borne by us and us alone. The effort of variation in the tolerances of rolled steel sections, the importance of clamping down all the members adequately the need of preparing accurate profiles of mating components and the imperative necessity of maintaining a welding sequence were valuable lessons learnt by toil, and fortunately, a minimum of tears.

END STRUCTURE



THE SUPERSTRUCTURE

The shell, which houses the equipment, is a framed structure, comprising of the nose, cab, sides, roof and inside partitions. Here again jigs were made, sub-assemblies produced, checked and rectified to meet the rigid demands of the subsequent stages, with ingenuity derived from necessity. Panelling of the superstructure called for variations in level of not more than 1/16". The design of the body had limitations, which called for considerable care in getting a satisfactory finished exterior. The absence of suitable machinery notwithstanding a reasonable quality by hard work alone, has been achieved.



ELECTRICAL EQUIPMENT

The filling in of the empty shell with cables for the high tension and control circuits was undertaken after considerable planning. The tasks had to be broken down into salient elements so as to enable the unaccustomed operator to translate the sketches into reality. It is to the credit of our able electrical staff that all the operations were completed including 1200 terminal connections with only one cross connection.

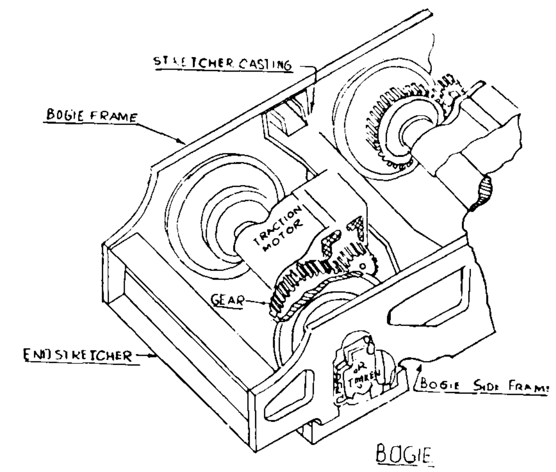
This performance for a first effort was remarkable enough to earn the applause of at least one manufacturer overseas. Conduit work for housing the cables although similar to pipe work had to be processed to a standard not usually found in steam practice. The mounting of the auxiliaries did not in themselves present any difficulty except that not being familiar with the sequence of fitment additional labour became necessary to locate components left out at first.

PIPING

The Electric Locomotive depends on compressed air for its control circuits and sanding gear to function. The demands of the latter are considerable, making compressed air capacity of a large magnitude essential. The lessons learnt in getting 250 pipes with a total of about 500 joints to admit of a drop in pressure of about 10 lbs/sq. in. in a period of one hour, were severe, but unforgettable.

BOGIE

Bogie design takes into consideration riding qualities



BOGIE

weight transfer at starting, besides protecting through suitable cushioning systems the effect of track variation on the motors. The DC Loco bogie comprises of two slabs of 3" thick welded to form a length of 22', which are braced by stretchers. The body rests on bolsters, which are mounted on coiled and laminated springs. The bolster and central stretchers are large steel castings, which consume a not inconsiderable amount

Filtration Equipment for Diesel Locomotives

By An Engineering Correspondent

THE space factor in diesel locomotive construction is a problem that is always uppermost in the mind of the filter designer and this obviously has considerable bearing on the type of filter produced. He has to design the filters to fit into the space allocated by the locomotive designer to give the utmost efficiency and so arranged as to be easily serviced. The filtration of intake air to the engine and generators is equally as important as the necessity to filter the lubricating oil used in the engine and other locomotive equipment. In fact, the two are inseparable for if the contaminants in the air are free to mix unhindered with the oil, the contaminating agents reduce the lubricating efficiency and hence increases the overall wear and tear of moving parts. The ultimate effect is to rapidly shorten the periods between servicing and also reduces the life of the equipment which is reflected in increased and uneconomic running costs. Through considerable research, development and running tests on diesel locomotives over many years, Vokes Limited are able to offer a range of filters for air, fuel and lubricating oil application capable of meeting the requirements of diesel locomotive manufacturers. The filters have been designed to protect the manufacturer's equipment in such varying conditions as extreme cold, intense heat, heavy industrial atmosphere, heavy dust and sand concentration.

Vokes range of panel filters for air filtration include the 3-Ply (Oil wetted), 5-Ply (Oil wetted), W. M. S. and H. W. also oil wetted. The 3-Ply is a constant efficiency type the medium consisting of two layers of wire mesh and a single layer of cotton gauze between. The 5-ply which is also of the constant efficiency type 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. Both these filters are deeply pleated to increase the total developed area to a maximum. The W. M. S. panel is a reducing efficiency type with an element consisting of a folded woven mat interspersed with layers of corrugated expanded metal, the whole housed in a light, strong 2" deep metal surround. Another reducing efficiency type is the H. W. panel which has an element consisting of layers of approx. 2" wide chevron-crimped wire gauze, alternating with shallow crimped interspacers throughout the height of the panel. To complete the range of penels, there is a special neoprene bonded hair type which is used for turbo blower intakes. These panel filters have given first class service for over twenty years.

Vokes have also a wide range of fuel and lubricating oil filters, one of the most important being the Top

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(Continued from page C.L.W.7)

of machining capacity. The axle boxes are fitted with roller bearings.

LABOUR & COSTS

The ratio of labour on these DC Locos mechanical to electrical work is estimated to be about 6 : 1. This proportion will vary in accordance with the nature and extent of sub-assemblies undertaken in subsequent builds of diverse designs.

A break-up of the estimated cost of the DC Loco is briefly as follows :—

Electrical Equipment	Rs.	6 lacs
Mechanical Raw Material	Rs.	1.40 lacs
Labour & Overheads	Rs.	1.32 lacs
Bought out Equipment	Rs.	1.49 lacs
Total	Rs.	10.21 lacs

In retrospect the obstacles overcome seem like mole-hills where once they assumed the proportions of Leviathans but dogged perseverence now finds us with the confidence of a big objective successfully attained.

The future holds promises of more varied types of locomotives, each aiming at higher economies of operation, more reliable equipment, revolutionary designs of bodies and bogies. Techniques are changing and continue to change with breath-taking speed. Our role as Electric Loco builders is in its embryonic stage, but when it flowers into maturity we shall add lustre to our prowess which has always been, second to none.

Servicing Lubricating oil filter. Apart from embracing all the performance characteristics of their other lubricating oil filters, it has the additionally unique method of servicing. The filter insert is so constructed that the minimum spares are necessary for servicing. The only replacement parts required are the high grade felt element which is backed with stout wire gauze and two felt end-pads. The insert is supported by means of a spring which also controls the operation of the filter by-pass. The functioning of the filter is for the oil to enter the inlet port and then it is directed to the inside of the insert assembly from whence it flows through the element to the outlet port. Should the element become choked due to neglect of servicing, the pressure exerted by the spring is overcome and the whole insert assembly moves downwards, thereby allowing the oil to pass directly from the inlet port to the outlet port across the top cap. This " built-in " by-pass ensures that the lub. oil circuit or system can never be starved of oil through choking of the element. It also possesses the added advantage of permitting the oil to by-pass the element without taking back into circulation any previously collected foreign matter.

The simple method of servicing gives the Top Servicing Filter an advantage over the more conventional types. All that is required is for the clamp-ring or bolts to be unscrewed, the removal of the cover plate and inner seal and the element is easily withdrawn. The clamp-ring type can be locked in any radial position which makes it particularly useful for confined spaces. It has been designed specifically with a view to reducing maintenances time to a minimum with the attendant saving in costs. A particularly outstanding feature in locomotive application where restricted space is a primary consideration.

Hydraulic braking systems employing compressed air is constantly subjected to water and oil content together very often with dirt and scale from pipe lines. Such contamination is inevitably found in every compressed air installation. In addition, there are many applications where compressed air is used in connection with railway maintenance, particularly in railway workshops and running shed. There are also many uses for pipe line filters in power and generating stations such as on air-operated switchgear equipment. Air compressors also need pipe line filters and this is particularly so in such working conditions as tunnelling where impure air exhausted by compressed-air tools can be injurious and dangerous to the health of workmen.

The ideal pipe line filter is one which will exclude the possibility of any impurities reaching the machine tool or equipment from any source, trap and retain them in such a manner that they can be easily removed. It is essential that it must do all this with a high degree of efficiency, continuously and without excessive maintenance costs. It must also on no account offer undue resistance or restrict the rate of air flow. Judged solely by their performance, Vokes' Pipe Line filters are ideal for this purpose. They have a proved efficiency rating of 99.9% and are simply designed for a long life with all parts easily accessible for servicing.

In many large buildings connected with railways such as stations, office buildings, large signal boxes and on electrified systems where power and generating stations are concerned, there is a requirement for the filtration of large volumes of air. This is particularly so in climates where there is an atmosphere which is frequently charged with fine dust and other contamination. For such applications, Vokes manufacture several filters which can be used as single or multiple units depending upon the volume of air to be filtered.

The latest Autoroll Mk II is not only relatively cheap to install, but maintenance costs are reduced to a minimum both in terms of labour and materials. Entirely automatic, in operation, the effective area of the filter medium—composed of a fire resistant fibrous mat—is disposed between an upper spool containing clean material and a lower one, soiled material, the whole of which is intermittently moved across the face of the filter by a pressure differential switch or timer. Features of design are simplicity of construction, minimum of wearing parts, speed of servicing and utilisation of the maximum filtering area. It is available in all-electric or manually operated form.

A similar type of fully automatic filter is the S. C. Rotary Screen which has high dust holding capacity. The element is composed of special panels which constantly circulate through a trough of oil which employs a unique cleaning device. The only servicing required is the periodic removal of sludge and the maintenance of the correct oil level. The S. C. is of robust welded construction with drilled flanges to facilitate rapid assembly of multiple units for the largest air flows without the necessity for complete inter-connection of the driving mechanism.

For general air conditioning systems where

BICC Collaborate with B. R. Eastern Region to develop new Pantograph Test Train

THE results of a recent collaborative effort by the Research Organization of British Insulated Callender's Cables Limited and engineers of the Eastern Region of British Railways are to be seen in the production of an overhead equipment Test Unit for use on the overhead electrification schemes in the Region. The purpose of such tests is to ensure that the already good current collection can be improved wherever possible. The BICC Group, as one of the principal contractors for the British Transport Commission's modernization plan, were responsible for the high voltage a. c. overhead electrification equipment on all the Eastern Region lines included in the plan.

In order to ensure that the initial high standard of current collection is maintained in service, the Instrumentation and control Department of the BICC Research Organization and the Chief Mechanical and Electrical Engineer, Eastern Region, have collaborated closely in the development of a Test Unit capable of travelling at speeds of up to 100 m. p. h.

The Test Unit comprises an instrumented coach, fitted with two pantographs, and generator coach which provides the electrical power for the instruments, lighting and heating, An electrically driven air compressor in the generator coach provides the air supply for raising the pantographs.

The instrument coach, or Test Coach, was converted at the Doncaster Carriage Works from a normal passenger vehicle, so as to have a central observation dome and flat roofs at each end, both of which were fitted with Stone Faiveley type AMBR pantographs. Close liaison was maintained throughout the conversion period to ensure that the internal coach layout, cabling ducts, power points, lighting points, air lines, roof and floor cut-outs, high voltage bushings, etc., were positioned suitably for the later installation of the instrument panel and associated equipment.

The instrumentation of the Test Coach was carried out in a siding adjacent to the BICC Research Laboratories at Wood Lane, London. The majority of the instruments are contained in an instrument panel, 12 feet long x 18 inches wide x 6 feet high, which is secured to both the coach floor and roof by anti-vibration mountings. The panel is mounted below a pantograph which is earthed to the coach and is designated the " dead " pantograph. The " dead " pantograph is used during tests when the overhead line is earthed and the Test Unit is being hauled by a diesel locomotive. At the opposite end of the coach is a high voltage enclosure which is situated below a " live " pantograph insulated for 25 kV, which is used during tests with the overhead

(Continued from page C. L. W. 10)

smaller volumes of air are involved, there are many types of filter panels including the Vokes' Super Vee. It offers a high degree of efficiency at exceptionally low cost and is most useful where heavy ' Smog ' conditions prevail or the atmospheric contamination is generally at a high level.

Air filters of all these types although mainly aimed at the removal of atmospheric dirt and dust, also perform a useful service in trapping bacteria which in air suspension, nearly always tends to be associated with dust particles larger than themselves. As a result of this tendency, many bacteria which would be small enough to pass through a filter quite easily if on their own, become effectively trapped when associated with dust.

For many years Voke's filtration equipment has been accepted and used in railway system expansion programmes as the first line of defence against atmospheric pollution and contamination of all kinds. It has played a very valuable and important part in protecting railway equipment both in Great Britain and overseas.

line live and with a diesel or electric locomotive hauling the unit. Arrangements have been made so that the electric locomotive can draw its power from the " live " pantograph on the Test Coach so that the overhead equipment is not disturbed mechanically other than by the measuring pantograph.

The quantities which can be measured and recorded are : pantograph height, acceleration, contact loss, contact pressure (" dead " pantograph only) locomotive current (" live " pantograph only), and train speed. In addition, track marks and timing marks can be inserted on all recordings. The selection for recording of any combination of measured quantities is effected by the use of jacks and sockets on a distribution panel on the console.

The recording facilities comprise one 4-channel " high speed " recorder and three 2-channel plus event mark " low speed " recorders. The former has a good frequency response up to 1000 c/s and the latter up to 25 c/s. All recorder charts are driven by stepping motors controlled by a stepping switch transmitter attached to a velodyne unit, which receives its control signal from a tachogenerator attached to a coach axle. The chart speeds are therefore proportional to the train speed and the recordings are made on a distance basis. A track distance of 100 feet is equivalent to chart lengths of 20 centimetres and 1 inch on the high and low speed recorders respectively.

Pantograph height is measured directly by a specially designed linear potentiometer, some 7 feet long, driven by a lightweight glass-fibre tube attached to the pantograph-head. Strain gauge accelerometers attached to the hight gauges measure the pantograph-head accelerations. Contact pressure is measured by two strain gauge ring dynamometres fitted into the pantograph-head, one at each side, the outputs being added to give the total force on the head. When running with the overhead line live, the line voltage is measured by an instrument transformer and displayed on a meter and recorded so that loss of electrical contact can be easily seen.

In the case of dead line running, a 300 volt d. c. circuit is completed via the pantograph, the overhead line and earth. Loss of contact is measured by recording the voltage swing in a section of the circuit. Track marks can be inserted on all recordings either manually or automatically. A lamp and photo-cell unit, mounted under the coach floor and vertically below the pantograph, is arranged to operate the track mark unit from a piece of aluminium foil placed on the track. Manual insertion of track marks can be made by pressing buttons in the observation dome or on the instrument panel. The traction current taken by the hauling electric locomotive is measured by a current transformer on the connecting cable between the locomotive and the Test Unit.

The Test Unit, which has recently gone into service, is similar in many respects to one developed earlier by BICC for the Midland Region of British Railways. It will travel on all parts of the Eastern Region where lines are, or are being electrified. Such lines include the Liverpool Street-Southend line converted in 1960 from 1500 volts d. c. to the British Railways standard high voltage a. c. system.

In addition, the apparatus will be used to test the overhead equipment on the North East London lines, also completed in 1960. A further important function of the new high-speed pantograph Test Unit is to check the overhead equipment on the Fenchurch Street-Shoeburyness line, and also to ensure that the equipment between Chelmsford and Colchester on the line between Liverpool Street-Clacton/Walton is entirely satisfactory when the new electrified service begins to operate.

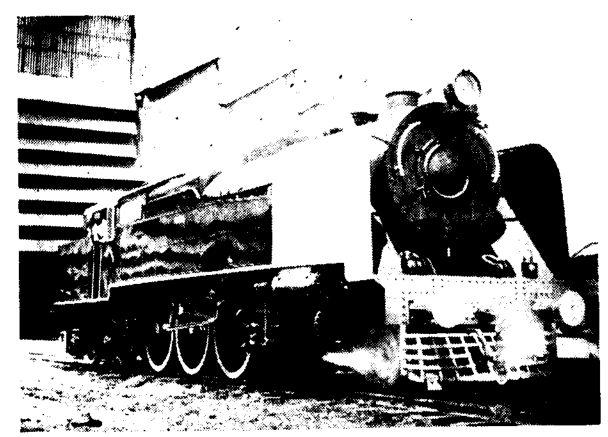
This is the practical side to the work being carried out to ensure that overhead electrification in the Eastern Region is as near 100 per cent perfect as possible. On the theoretical side experiments in the mechanical problems of current collection at high speeds continue to be conducted with models at the BICC Railway Traction Research Laboratory at Tolworth, where considerable progress has been made.

CHITTARANJAN - 1975

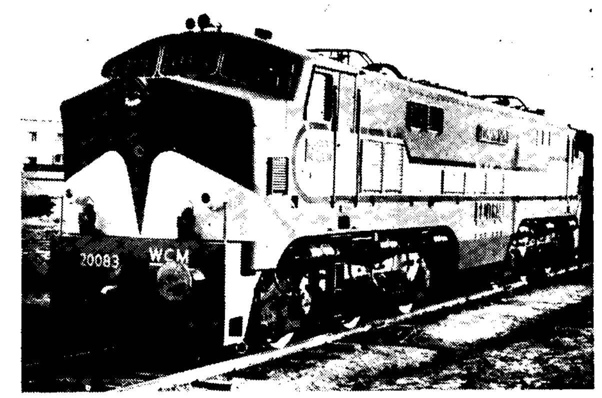
By C. Chalapathi Rao
Chief Mechanical Engineer,
Chittaranjan Locomotive Works, Chittaranjan

WHEN I was recently abroad in Europe visiting the Works of Locomotive Builders and discussing with them problems of Locomotive building Industry I gathered some very interesting information. This information made me think of some of our problems today. I suddenly felt an impulse to project the problems in Europe today and to see how they will affect this great undertaking of ours in 1975. The year 1975 was selected by me as by then we would have completed 25 years of production.

In spite of development of Jets and Space exploration and travel around the world now being a matter of hours instead of months and days, Railroads play such a vital role in the economy of a country that nobody is thinking of displacing them entirely by an alternate mode of transport. To compete with air travel vast sums of money are being spent to provide fast and luxurious travel in many countries. An example of this is the Trans Europe Express trains connecting principal cities in Europe. In times of emergency Railroads are the principal means of transport. We can, therefore, assume that Railroads will stay all over the world irrespective of any developments and quite serious competition.



WT Suburban and Branch Line type locomotive prototypes of which were manufactured in Chittaranjan Locomotive Works.



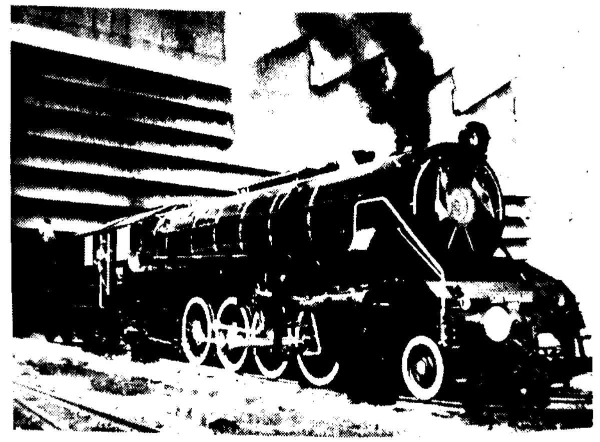
D.C. 3600 H.P. Straight Electric Locomotive now manufactured in Chittaranjan Locomotive Works.

The fact that Railroads will stay does not necessarily mean that Locomotive building industry will also survive without any difficulty. The change from Steam traction to Diesels and straight Electrics after World War II has put a number of Locomotive builders all over the world out of business. Today in Europe, some leading Locomotive builders, who have not yet been seriously affected because they foresaw the future well in advance and took some quick decisions to re-organize their industry, feel that business outlook in another 5 to 10 years will be gloomy because of the restricted home and dwindling foreign market. Some of them feel that unless some revolutionary types of locomotives are developed within the next 5 years, they will have to close down. The 4000 H.P. Diesel hydraulics with dynamic braking is one example. There are talks of developing 4800 H.P. Diesel Electric and Diesel Hydraulic locomotives weighing 76 tons. Bogie designs which permit a gear shift on the run to convert them from low tractive effort to high tractive effort locomotives and vice-versa to suit the terrain and service are being developed. The latest thought centres around building mechanisms which would enable conversion of heat energy direct to electrical energy.

The conditions in India are not the same as in Europe. We do not necessarily have to depend on revolutionary developments to keep our industry going. In our country, with a rapidly developing economy our needs are so great that capacity developed will continue to be absorbed for several years to come. A rough estimate of our requirements by 1975 would be about 20,000 locomotives against which we have now a little over 10,000 locomotives. Between now and 1975, with the proposed output of Steam and Electric Locos, we will be supplying the Indian Railways about 2,200 steam and 800 electric locomotives. The new factory being set up at Varanasi for manufacture of Diesel Locomotives could be expected to produce about 2,000 Diesel locomotives by 1975. Although each Diesel and Electric locomotive can be equated to about 2½ steam locomotives, taking into consideration scrapping of a certain number of old locomotives, our production is likely to just meet the needs. For all practical purposes, therefore, our locomotive industry is not likely to face the same problems as in Europe.

There is however one very important problem which I felt was worth remembering and acting upon. This is in regard to the future types of locomotives. Very often a number of theoretical calculations get completely upset on account of (a) Traffic density and (b) what I would term, fashion of the day. To briefly elaborate the above factors, if between points A and B the traffic density is very heavy, putting in a large number of steam locos of the designs we are now building into the section will not help. Similarly, if on a Railway operation is efficient on account of modern types of traction like Diesels and Electrics, another Railway which may not have the same type of traffic problems will still feel that the only solution for improving their operational efficiency will be to get these modern types of motive power. With such possibilities, rapid changes of design, and production of more powerful locomotives will have to be planned for by 1975.

We are setting up a Steel Foundry with a capacity of 10,000 tons of steel castings per annum. This Foundry would be working to its full capacity by 1967. New alloy steel plants are coming up in the country. New types of metals are being developed in various countries to cater for the Jet and Space age. These developments taking place in and outside the country will influence to a very large extent the designs



WG Freight type locomotive manufacture in Chittaranjan Locomotive Works.

of more powerful motive power units. I anticipate some of the techniques developed by us so far, dealing with straight carbon steels mostly will be completely out of date by 1975. Welding techniques which have been developed and which would be developed in the next decade are likely to be used extensively rapidly replacing the present conventional rivetted and bolted type of constructions. Extensive use of roller bearings in place of plain metal bearings would be resorted to with a view to reduce frictional resistances and maintenance problems.

I have tried to peep into the future. To those who have been studying this industry or watching the progress of this industry these assumptions may not appear to be new. My intention in deciding to write this article has been to bring to the notice of your readers that we in Chittaranjan are alive to the problems of modern transport and we will not lag behind in the rapid development of this great country of ours.

Dimensions for Shank Diameters and Driving Squares for Rotating Tools

The Indian Standards Institution has just published IS : 1850—1961 Dimensions for Shank Diameters and Driving Squares for Rotating Tools, which specifies the preferred diameters of shanks and dimensions for external and internal squares provided for rotating small tools.

Squares are provided on the shank ends of small tools, such as reamers and screwing taps for holding and driving. In some cases, an internal square is provided.

PERSONNEL MANAGEMENT

By R. G. Hardikar,
District Electrical Engineer (Steel Foundry),
Chittaranjan Locomotive Works.

[In the following article, the author narrates a few remedies already applied on Indian Railways and hopes that Chittaranjan Locomotive Works will soon be an object lesson in Personnel Management — Ed.]

IN the words of the Prime Minister Jawaharlal Nehru, Chittaranjan is "a symbol of progress that our Railway system is making not only in building up of our own locomotives but in so far as the human factor is concerned, that is how the workers who run the factory are looked after and cared for". This raises the question, what is there in Chittaranjan which others haven't got? In Chittaranjan except to unskilled and semi-skilled staff who come from neighbouring villages, quarters are provided to all others. Even for these categories, for the benefit of displaced persons and of those coming from far off places, quarters to the extent of 50 per cent have been provided. These quarters are much more comfortable than those elsewhere on other Railways. Even the lowest paid worker is provided with a two-roomed dwelling. Therein he has a covered back verandah, a court-yard, and a flushing-type lavatory, that works. It is electrified and has a water tap of its own inside. Nor is the necessity of providing the ex-cultivator with a small plot of land for gardening and growing vegetables or 'a green patch' lost sight of.

GOOD NEIGHBOURLY RELATIONS

To promote civic sense and good neighbourly relations among multi-lingual residents in different areas (mohallas) Committees of elected occupants are formed. These Area Committes help maintain sanitation and general cleanliness and settle disputes between neighbours on village panchayat system. Each area is provided with a Community Hall. It is a meeting place, call it a Town Hall if you like. There entertainments, poojahs and such other functions are organized on a community basis with local voluntary collections.

Besides these committees there are the usual Institutes or Clubs. These hold regular cinema shows and provide indoor and outdoor games. Reading rooms and libraries are also there for the more serious minded.

NEW APPROACH

Inhabitants of Chittaranjan hail from all corners of our vast country. This incidentally offers the best field for the much talked of social and cultural integration. The author believes that the quickest way of attaining this goal is to form hobby groups or circles where people with like interests exchange views on their pet hobbies. People who live alike think alike. Formation of groups for (i) gardening, (ii) music, (iii) theatricals, (iv) painting and photography, (v) penmanship, (vi) elocution etc. open to all staff irrespective of their positions in the heirarchy, wherein their families also can join, is worth trying. Will Chittaranjan lead the way?

It is a universal experience that the aged and the well-settled do not like a change. They detest it, nay oppose any move to alter standard, values or the norms. They are blissfully oblivious of the all pervading atmosphere of Evolution. It is noticeable in all human relations, be it marriage, commerce, industry or politics. It is noticeable in dress and arts. Outdoor sport not excepted. The artist who created the CLW crest depicting the bow and arrow superimposed on the driving wheel of a steam locomotive told the author that it is incorrect to believe that the arrow symbolizes speed like Mercury or Achilles' tendon. "The arrow associates or brings out simply," the artist added, "the opposition put up by local Santhalies in the early days (1948) of construction of this Locomotive Building Project when their ancestral villages lands were being acquired. They rushed out with their primitive bows and arrows to defend the status quo."

Eleven years (1959) later when being driven on official duty in a Land Rover over rugged village tracks through a certain village to another, called Sidhabari, nine miles away from Chittaranjan, the writer was amazed to behold a youth of 25 or so taking his mother pillion riding on his push bike. It is to be noted that the Mum was not modern enongh to don a blouse.

CHANGING RELATIONS

Within a decade the wheel has come into the villages outskirting Chittaranjan. In the early days of industrialization in New England (U. S. A.) factory workers had broken up labour-saving equipment. To-day they themselves are preaching to their opposite numbers in industrially less advanced countries the lesson that a costly plant lowers production costs despite higher wages paid to operatives who man it.

Likewise, nations all over the world have marched forward towards healthier human relations in industrial undertakings. Serfdom of feudal days has been replaced by democracy in commerce and industry. At the beginning of the industrial revolution in England priests and magistrates were nominated as factory inspectors. Little wonder then that they looked down upon factory workers with special disdain, as scamps and drugs of society. At the end of the first world war Trade Unions in Europe took up training of workers so that the employer finds them gainful. The employees, on their part, found training an insurance against periodic unemployment. The research for more and more production in industrial undertakings during and after the second world war led the manufacturer to undertake training of his employees himself and at his own expense.

America on the other side of the Atlantic, has progressed even farther. She has earnestly taken up the problem of colour prejudice and discrimination shown to almost a tenth of her population. It is progressively being realised and openly admitted that prejudice and discrimination hold back the downtrodden in pulling their weight towards the fullest realization of ' American Way of Life '. Such discrimination is considered not only morally bad but hampering further improvement in industrial production which is already reckoned to be the highest in the world. Not 'isms but a progressively rising standard of living brings about greater and greater output.

ERADICATE DISCRIMINATION

Years before the outbreak of the Second World War, there have been progressive and able administrators on Indian Railways who realised the growing importance of building up human relations to properly operate any transport system. A couple of years or more before the attack on Poland on 3rd September, 1939 the Loco. & Carriage Superintendent of a very small Company-managed Railway invited applications, on recommendations of his works Manager, to fill in the post of a Chargeman on Rs. 150/- p. m. (Fixed). The advertisement for this was inserted in prominent English dailies published in Delhi, Bombay, Calcutta and Madras. In due course a rank outsider was recruited. The Company's employees felt that at least before resorting to outside recruitment they first ought to have been tested and found unsuitable for promotion. The disappointed personnel appealed severally and jointly. Due and careful consideration was given to these appeals. The competent authority found no reason to change its already adopted policy. This did not deter the 150 odd men. They had a legitimate grievance. They approached local Congress workers and trade unionists and sought for their advice. Through the vernacular Press they brought to light how their legitimate aspirations to improve their status were checkmated. This had the desired effect. The Agent on learning of this discontent called for papers and appointed two assistant officers to test the existing eligible personnel before confirming the new entrant who was on one year's probation. The Committee, after a strict written and practical examination, recommended two men as suitable for promotion. The outside recruit was advised that his services were no longer required. One of the two men recommended was promoted. The other was kept on Panel for absorption in the event of any future vacancies.

Is it any wonder then that a few convenanted Foremen on the same Railway approached their Works Manager to permit them to have a word with the Chief Engineer during his inspection of the Workshops? They wanted to put forward their complaints about repairs to their bungalows. They hesitatingly enquired how the Company could find Funds to build a road up a small hill to enable an assistant engineer to drive up to his solitary bungalow on top of the hill. His predecessors, for over years used to lock the car in the garage at the foot of the hill and foot up the steep flight of steps—rain or shine, day or night. The Chief Engineer straight away visited the road under construction already half-way up the hill. He also inspected a few of the bungalows complained about. On being personally satisfied about the genuineness of the complaint and apparent discrimination the Chief Engineer, that very day, ordered stoppage of any further work on that road and diverted funds to the repair of foremen's bungalows.

Discrimination of any sort, especially in promotion or in recruitment is Enemy No. 1 of the growth of healthy personnel management. Instances are not wanting even to-day where the unscrupulous interpret Rules to suit the merits (advantages) of a particular case. In 1958 recruitments of unskilled men in grade Rs. 30—35/- were made in two of our neighbouring Railways. The physique of applicants in one recruitment was checked-up in the presence of other aspirants. No untoward incident cropped up. In the other case the measurements were taken behind closed doors. And when the candidates waiting outside had found reasonable cause to suspect favouritism they straightaway took the law in their own hands, broke up furniture etc. within the closed door and destroyed whatever office papers they could lay their hands on.

COMMON OBJECTIVES

For some reasons discrimination and complacency often evidenced at all levels in justly dealing with delinquents found responsible in cases of accidents, thefts, defalcation etc. undermines prestige of Management and promotes indifference, insincerity and inefficiency in its wake amongst the rank and file of personnel. After all, an individual's moral actions are judged by the sacrifice he does, while those of the Management from the Justice it metes out to its employees. Furthermore faulty and inefficient Personnel Management, apart from casting a slur on the Management concerned, results in betrayal of the cause: Mass production for mass consumption at progressively diminishing costs. A truly humanitarian and utilitarian objective. To achieve lower production costs the management and personnel must have identical interests in the success of the undertaking. Not profits but service to humanity is the aim.

Believe it or not! The night before the Club Dinner to Kumari Anita Bose during her visit to Chittaranjan in February 1961 a sophisticated young thing enquired:

" Who is Anita Bose ? "

" Daughter of Subhas Bose ".

Back came another query from the same source.

" Who is Subhas Bose ? "

It will be interesting to learn, therefore, how deep in the mass of industrial personnel either in Chittaranjan or Jamshedpur, the cause or reason for Miss Towy-Evans' (I. L. O. expert) visit and investigations had penetrated. It is learnt from Hawthorne Studies in well-being of industrial workers in U. S. A. that the production per working hour of a group of workers increased uniformly and continuously during investigation for several years without being affected to any appreciable extent by changes in the physical environment: alterations in lighting intensity, rest periods etc. The explanation was thought to be that the personnel felt that a genuine and sincere interest was being taken in them and their well being by their Management.

Purchase of 125 Diesel Locos for Indian Railways

The U. S. Government will provide foreign exchange to India for the purchase of 125 diesel locomotives for the Indian railways, the U.S. Ambassador, Mr. John Kenneth Galbraith, announced in New Delhi.

The U.S. Agency for International Development (U. S. aid) has approved a loan of 35 million dollars (Rs. 16.27 crores) for the purpose.

This brings American assistance for the expansion and modernisation of the Indian railways so far to 195 million dollars (Rs. 93 crores).

The U.S. has so far financed the purchase by the Indian railways of nearly 300 diesel locomotives. This compares with an estimated requirement of 556 diesels to be brought into service during the Third Plan. In addition to the diesel locomotives, financing has also been provided for acquiring electric locomotives and coaches, centralised traffic control equipment, structural steel, and various other types of material and equipment.

To-day's loan announcement covers the purchase of one hundred 2,600 H.P. broad gauge locomotives and 25 metre gauge locomotives of 1,400 H.P. The diesels will be used to move freight in sections where the carrying capacity of steam locomotives has reached the maximum.

LOCKHEED AVERY SELF-SEALING COUPLING

LOCKHEED Precision Products Ltd., of Speke, Liverpool, England are known all over the World for their contribution to the Aircraft and Hydraulics Industry. Among their many famous products perhaps one of the best known is the Lockheed Avery Self-Sealing Coupling now used by British Railways on all their Diesel Locomotive stock.

Lockheed Precision Products have been closely associated with the modernisation of the British Railways system since the programme commenced in 1953/54. At that time the British Transport Commission decided to Dieselise their motive power stock by building large numbers of Railcars and Locomotives.

One of the problems encountered was the filling of locomotive fuel Tanks from ground equipment. Two main conditions had to be satisfied, namely the under filling of some of the Tanks and the prevention of spillage.

The Lockheed Avery type of Self-Sealing Coupling was found ideally suitable for the purpose and has now become a standard fitment.

The Coupling consists of two parts—the "Fixed Half" secured by flange or screw thread to the fuel tank and the "Free Half" fitted to the Hose on the fuelling crane. The latter is provided with a Handwheel promoting easy and quick connection.

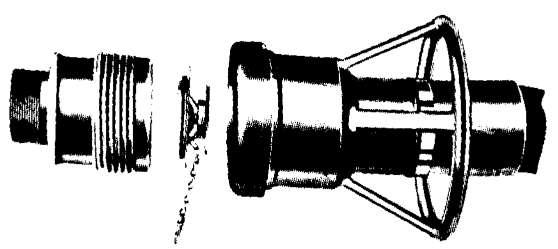
When the two halves are connected for refuelling the sealing valves in both parts are automatically opened allowing for free flow of the fuel. No other valves or shut-off devices are required.

The self-sealing characteristics of the Couplings ensure complete safety by closure of the supply lines under all conditions eliminating spillage, seepage and atmospheric evaporation when connection and disconnection is in progress.

On the original design of Railcars the flexible Hoses connecting various components situated in the under frame were of the jubilee clip fastening type. Following a few weeks in service it was found that this method of fastening was totally inadequate for the arduous work involved. Vibrations set up by movement of the Cars were sufficient to cause premature failures in the life of the Hose.

The Lockheed Avery type of renewable end fittings was introduced with immediate success and all Railcars are now so fitted.

These Hose Assemblies are used for conveying fuel to the engines and compressed Air to various control points.



Self-Sealing Coupling

The speed of the Engine is determined by what are known as "Throttle Motors"—there being 4 to each Engine corresponding to 4 positions on the "Deadmans" handle controller. The Throttle motors are mounted directly on to the engine the flexible suspension of which prevents the use of rigid tubing. Hence the need for flexible piping.

Similarly there are several other controls on the Railcars which have to be connected by Flexible Hose for the same reason. Altogether as many as 32 Hose assemblies have been required on the one car.

For the conveyance of all kinds of fluids whether liquid or gaseous, Lockheed Avery flexible pipes provide the complete answer and where flexible pipe lines have to be repeatedly broken and re-made, Lockheed Avery Self-Sealing Couplings prove invaluable.

There is a vast range of these components available to suit all needs.

AN INTRODUCTION TO MAHINDRA-SINTERED POROUS BRONZE MATERIAL

IN collaboration with Messrs. Bound Brook Bearings Limited, U. K., Messrs. Mahindra Sintered Products Limited, Bombay, (a member of the MAHINDRA & MAHINDRA Group) are now manufacturing at their modern well-equipped factory at Pimpri, near Poona, Sintered Bronze bearings, thrust washers etc.

MAHINDRA SINTERED BRONZE—WHAT IT IS :

It is a porous bronze material manufactured by a special process of Powder Metallurgy. The composition consists of the recognised anti-friction bronze 90% copper, 10% tin, and is of a strong and rigid structure due to a complete alloying of the metals during manufacture. The porosity is distributed throughout the material in the form of myriads of inter-connecting channels and reservoirs which are charged with lubricant. The capacity of oil retention is 25—30%, of the volume. This material is made up into bushes and bearings, also into other shapes consistent with the method of manufacture, and these parts are supplied finished to very close tolerances ready for use.

THE SELF-LUBRICATING PRINCIPLE :

The principle underlying the oilretaining and self-lubricating properties of these bearings is as follows :—

The finished bearing contains about 30% of oil by volume. As a result of capillary attraction and surface tension of the oil in the pores and on the outer surface a thin 'absorbed' film of oil is always present on the inner and outer faces. When a suitably dimensioned spindle or shaft is fitted this thin film 'wets' and separates the two bearing members. As movement between the spindle and bearing takes place, the initial oil film is augmented from the reservoir of oil in the porous walls of the bearing by each of the following effects :

(1) Speed of rotation of the spindle
(2) Increase in bearing pressure
(3) Increase in temperature of the bearing

Hence automatic lubrication is immediately built up and maintained by any of these three conditions, all of which are usually present in bearings when in operation. Furthermore the self-lubricating action is reversible in that when the shaft speed, load or temperature is reduced the amount of oil surplus to the altered conditions is re-absorbed into the pores of the bearings ready for future use.

The explains why is that MAHINDRA-SINTERED bearings maintain automatic lubrication over long periods without attention and with a minimum of expenditure of lubricant. In a comparative test with a bearing employing oil-cup lubrication it was found that the oil consumption was many thousands of times greater than with the oil-retaining bearing. In other words in the MAHINDRA-SINTERED bearing the oil is always ready to hand and in exactly the right place to lubricate the shaft.

WHERE THEY CAN BE APPLIED :

For practically every purpose where machined bearings have previously been used, Porous Bronze bearings can be substituted with additional advantages. These include—

1. "Built-in" lubrication—once installed require no attention to lubrication and give long life.
2. Elimination of oil grooves and holes
3. Elimination of grease cups and lubricators
4. Reduced wear and quiet performance
5. Reduced oil consumption
6. No oil leakage—contamination of manufactured articles avoided.
7. Oil cushion—the lubricant in the pores is forced up to the bearing surface by increase in load.
8. Low cost—competitive with ordinary machined bearings.

HOW TO USE THEM :

Porous Bronze oil retaining bearings are supplied finished to close limits of dimensional accuracy. This is attained by forming and sizing operations in high precision dies.

Besides plain cylindrical bearings, flanged types, spherical self-aligning and thrust washers are manufactured. Many special shapes such as ball seats, plugs, closed-end bearings and so forth can also be produced.

It will be appreciated that the high precision dies are expensive to make and cannot be suitably modified to produce bearings of diameters different from those for which they were originally designed; lengths, however, can be varied over a wide range. Hence the importance of selecting a STANDARD bearing diameter wherever possible.

PRODUCTS WHERE THESE ARE USED:

These bearings find a ready use and are successfully employed in agricultural tractors and implements, aircraft, conveyors, lifts and hoists, vacuum cleaners, cycle dynamos, lawn mowers, electric motors, fans, dynamos and generators, clocks, electric gramaphones, record players, tape recorders, machine tools, railways—signalling, interlocking and point operating mechanisms, office equipment, accounting machines.

In fact wherever a shaft or spindle revolves with continuous, intermittent or oscillating movement, there is scope for use of these oil-retaining bearings.

Method for Voltage Measurement by means of Sphere-gaps (One Sphere Earthed)

The Indian Standards Institution has just published IS: 1876—1961 Method for Voltage Measurement by Means of Sphere-Gaps (One Sphere Earthed) which specifies the requirements and the method for use of sphere-gaps (one sphere earthed) for the measurement of the peak value of alternating voltages; full standard voltage impulses and impulses with longer tails; and direct voltages.

Metric system has been adopted in India and all quantities and dimensions in this standard have been given in this system.

PAINTING OF CHITTARANJAN BUILT LOCOMOTIVES

By *K. C. Choudhuri, M.Sc. (Leeds) F.I.M., A.R.I.C., A.M.Ch.E.

INTRODUCTION

THE first WG type of steam locomotive built at Chittaranjan rolled out of the Works in November 1950. Till 31—1—62, 1310 WG locomotives—which are Indian Railways Standard for hauling heavy freight trains on broad gauge trunk routes—and 10 WT locomotives, designed for operating heavy shuttle service including branch line passenger and mixed trains, have been turned out. With an annual production of about 168 locomotives, the Chittaranjan Locomotive Works have already made the Indian Railways self sufficient in B.G. steam locomotives. The first electric locomotive "LOKOMANYA" a 1,500 Volt D.C. CoCo locomotive of 3,600 H.P., was launched on track from these Works by the Prime Minister in October last. It has been designed to work either of the two services, namely freight and passenger.

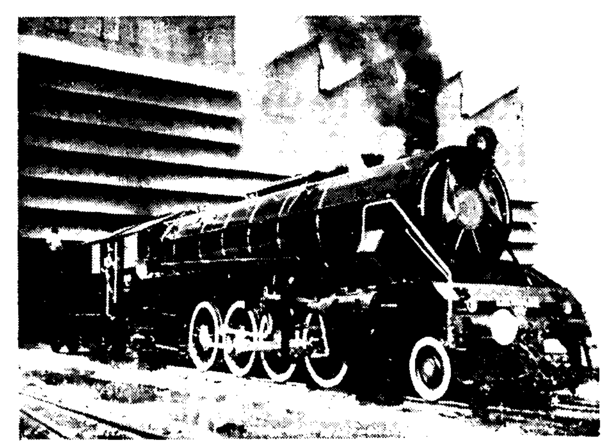


Fig. 1—Chittaranjan built W. G. Locomotive ready for despatch.

PROBLEMS IN THE PAINTING OF STEAM LOCOMOTIVES

Before describing the painting practices at present followed by C L.W. for the painting of locomotives and the steps being taken to standardise painting schedules based on recent developments in the field of paint technology, the practices followed in other countries and the researches carried out by the Chemical and Metallurgical Wing of Research Designs and Standards Organisation, Chittaranjan, it is necessary to indicate the special problems which the painting of steam locomotives presents. Perhaps the most difficult problem is to develop finishes for the fire box and front end which are exposed to high temperatures. The Eastern Railway, Jamalpur uses 2 coats of ready mixed black paint for the fire box and two coats of black Japan followed by a coat of varnish for the smoke box. The Southern Railway gives one coat of black graphite silica or one coat heat resistant black enamel on the smoke box and Chimney. In the Dohad shops of the Western Railway also black japan is used for painting the outside of smoke boxes. Some of the foreign railroads are stated not to use any paint at all for the fire box and front end since no finish lasts for any length of time. Some mix graphite with waste or crude oil and smear over these parts after each trip, wiping off the excess with waste. The protection thus afforded is not lasting; it is, however, better than having no paint at all. Special front end paints, containing graphite and small amounts of other pigments, semi-drying oils, waxes and solvents are also used for this purpose. It has been stated that for smoke box, frequent repainting with a cheap material appears at this stage to be the most economical.

Then not all the locomotives are steam tight in every joint and even the best lagged boiler has its exterior painted surface at a temperature not far below the boiling point of water. Released steam may swirl round the paint work at temperatures several hundred degrees higher. The coatings on the coal bunk are subjected to the abrasive and corrosive action of coal. While the finishes for the cab, cylinders, wheels, and tender need not be highly heat resistant, they as also finishes for the engine portion must fail uniformly by surface deterioration and not by scaling or flaking, be resistant to oil, alkaline cleaning solution and the boiler water treated with alkalies. The finishes for locomotives must also be of a durable type and resistant to sulphur and other corrosives in the air over

*Joint Director Research (Metallurgical & Chemical), Research Designs & Standards Organisation, Ministry of Railways, Chittaranjan.

industrial areas and the salt laden air near the sea-shore as well as to the effect of flying dust.

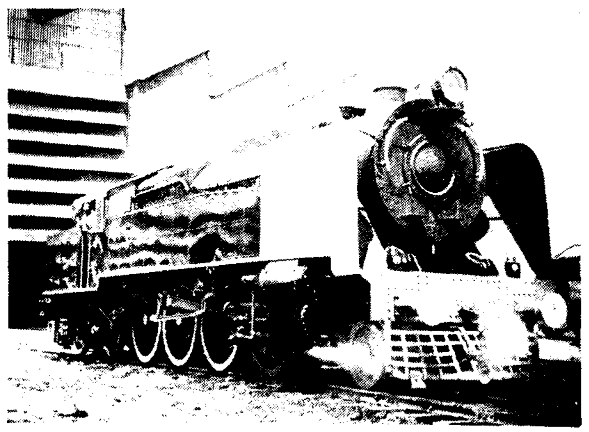


Fig. 2—W. T. Locomotive designed and built at Chittaranjan.

PAINTING PRACTICES FOLLOWED IN CHITTARANJAN

Painting of WG locomotives is carried out in a separate shop. The type of steel sheet and plate used for the tender tanks, cab sides and boiler clothing sheets has an uneven surface. Though it would be desirable to prepare the surface by pickling and phosphating or by shot blasting, at present only superficial rubbing with white spirit and emory cloth is carried out before the application of primer. The schedule currently followed in Chittaranjan Locomotive Works for the painting of outside of boiler, inside of boiler clothing plates, outside of tender, engine, fire box and undergears is given below :

PAINTING SCHEDULE FOR W. G. LOCO

1. Boiler : Cleaning and application of 2 coats of red lead paint.
2. Inside of clothing plates : Cleaning and application of 1 coat of red oxide zinc-chromate primer to IS : 107.
3. Tender : Cleaning
   - 1 coat of red-oxide zinc-chromate primer to IS : 107
   - 1 coat of filler to IS : 110
   - Putty
   - 2nd coat of filler to IS : 110
   - Wet rubbing
   - Under coating black to IS : 520
   - Black enamel synthetic to IS : 520 and synthetic varnish to IS : 524 (1 : 1).
4. Engine : Cleaning
   - 1 coat red oxide zinc chromate primer to IS : 107
   - 1 coat filler to IS : 110
   - Putty
   - 2nd coat of filler to IS : 110
   - Wet rubbing
   - Under coating black to IS : 520
   - Black Japan to IS : 1704
   - Glaze coat consisting of Black Japan to IS : 1704 and synthetic varnish to IS : 524 (1 : 1)
5. Smoke box : Cleaning and 2 coats of Black Japan to IS : 1704
6. Coal bunk : 1 coat of red-oxide zinc-chromate primer, to IS : 107
   - 1 coat black Japan to IS : 341
7. Under-gear : 1 coat red oxide zinc-chromate primer
   - 1 coat of black Japan to IS : 341.

FINISHING OF ELECTRIC LOCOMOTIVES

The painting requirements of elecric locomotives more closely approximate to those of the passenger carriages than the steam locomotives. They do not present the problem of heat resisting paints and usually are not washed as frequently. It is, however, not possible to employ the same methods of pretreatment like phosphating since the heavier gauge steel used for the super-structure is not readily obtainable in the smooth scale free condition similar to that of carriages.

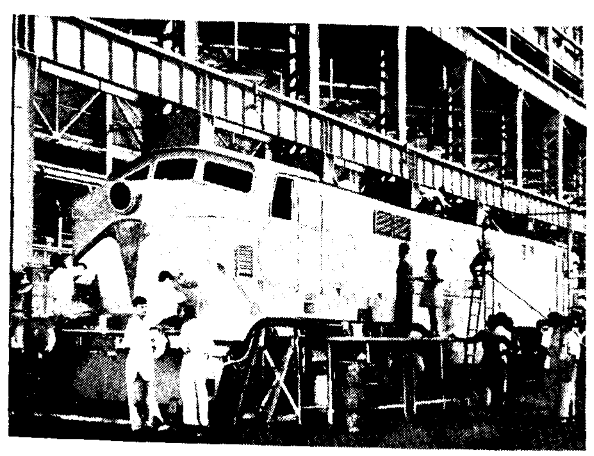


Fig. 3—First 1,500 Volt D.C. 3600 H.P. Electric Locomotive under painting.

The body exterior of the Electric Locomotives manufactured by the Chittaranjan Locomotive Works is finished in accordance with the colour scheme given by the Research Designs and Standards Organisation of the Railways.

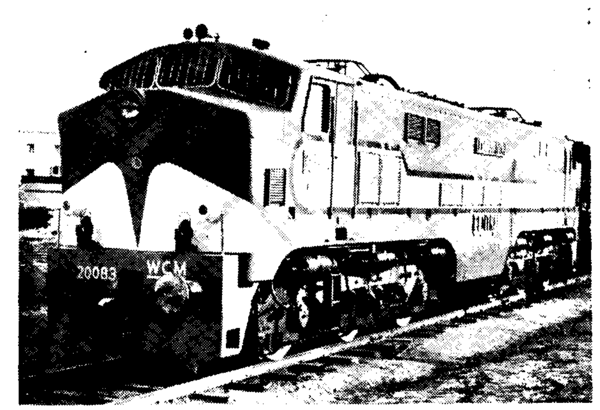


Fig. 4—First 1,500 Volt D.C. 3600 H.P. Electric Locomotive turned out of Chittaranjan Locomotive Works.

WORK ON THE STANDARDISATION OF PAINTING SCHEDULE

With a view to standardising the painting schedule for steam locomotives and deciding upon the types of paints to be used trials were carried out on 2 WG locomotives. One of these was painted with CNSL based compositions developed by Metallurgical & Chemical Sub-centre, Chittaranjan and the other with proprietary synthetic paints. When inspected after about one year's service, in the case of both the locos the paint was found to have been completely removed from a few locations on the engine portion which are exposed to the effect of steam, hot water, etc. The gloss of the synthetic finish was much better on the tender portion, as compared to the engine portion. C.N.S.L. paints, however, had no gloss ; the coatings were otherwise intact. Even after about 2½ years the loco painted with sythetic paint was found to retain its gloss though the paint had flaked off in patches from a few locations on the boiler barrel. On the tender portion there was blistering on the back and rear sides. Efforts are being directed towards evolving compositions more resistant to the effect of steam, hot water, etc.

Trials have also been carried out on 20 WG boilers using a primer based on red mud—a waste product of the Indian Aluminium Industry in place of red lead primer which is not only toxic but also based on imported lead. One of the trial boilers was inspected after a period of about one year and found to be in a better condition than a red lead primed boiler covering the same period of service. In this connection it may be mentioned that in the procedure for painting locomotives given on page 61 of the British Transport Commissions' Specification for British Railway Standard Locomotives and Tenders (January, 1954) one coat of mixture No. 36, composition given below, is specified for the painting of boiler.

Mixture No. 36 Bauxite paint

Boiled Linseed Oil	8 lbs.
White spirit	6–10 lbs.
Liquid Drier	2–4 lbs.
Bauxite Residue in Oil	82 lbs.

It is proposed to carry out further trials on a number of WG Locomotives with improved formulations based on CNSL and BNSL and compositions conforming to IS Specifications using different schemes. Based on the results of these trials a standard painting schedule will be evolved.

REFERENCES

1. Modern Organic Finishes by Rolling H. Wampler.
2. Paintindia, August, 1959.
3. British Transport Commissions' Specification for British Railways Standard Locomotives and Tenders, January 1954.

Mavoor Wood Pulp Factory

Production in the wood pulp section of the Gwalior rayon pulp factory started by the Birlas in Mavoor, 16 miles from Calicut, is expected to start by July next.

This was disclosed to Pressmen by Mr. G. D. Birla soon after he arrived by his own Dakota at the private airstrip constructed for the use of the factory at Chelari.

This is the first time that Mr. Birla is visiting Kerala since concluding an agreement with the Government for opening the factory in the State.

He was received by Col. T. P. Rajan, Chief Executive of the wood pulp division.

Mr. Birla thanked the Government and the public for the cooperation extended to him in starting the factory.

SILICA SAND FOR STEEL FOUNDRY

By C. S. S. Setty and J. Gupta

INTRODUCTION

GOOD Silica sand is one of the most important raw materials for production of good quality steel castings economically. As a part of investigation for raw material for the Steel foundry Project of the Chittaranjan Locomotive Works, investigation was conducted for the sources of Silica Sand.

In recent days considerable amount of work has been done by various Industrial and Research Organisations to study the availability of foundry sand and their properties. Some reports of the work are also published. But the work cannot be considered complete or adequate. The following is a note on the work done by us in this regard.

In advanced countries, silica sand is mined and processed to standard specifications at the source. The sand is washed and graded so that the consumer has only to decide the grade of sand required to suit his production and place an order on the supplier. By so doing not only the consumer can get the proper material but the byproducts which would be useful to other industry are economically utilized and the cost of handling of the waste material is reduced.

In this country there are no firms who can undertake to supply sand washed and graded at the source, with the result that each foundry has to depend on its own resources. Smaller foundries cannot financially afford to set up an elaborate washing and grading plant. Even for the large ones it may not be economical to bring raw sand with considerable amount of clay and off-grades in it, wash and grade the same, resulting in considerable loss of the material. Therefore, setting up washeries for washing and grading at the source by competent firms will be of great advantage to the foundry trade.

OUR NEED AND AIM

The castings required for the construction of a steam locomotive are varied in weight. The smallest casting weighs less than a kilogram, and the heaviest is as much as six metric tonnes. We propose to make as many of these items as possible in green sand moulds. For making these castings we need a medium fine sand, something similar to the Congleton sands of England which our Techical Collaborators are using. It was aimed to find a sand with properties close to the following specifications :—

CUMULATIVE MECHANICAL GRADING

BSS No.	10	= Nil.
,, ,,	16	= ,,
,, ,,	22	= ,,
,, ,,	30	= 1.0%
,, ,,	44	= 7.0%
,, ,,	60	= 42.0%
,, ,,	100	= 88.0%
,, ,,	150	= 98.7%
,, ,,	200	= 99.5%

Chemical Analysis :—

Silica Content	97.5% Min.
Oxides of iron	0.5% Max.
Oxides of Calcium & Magnesium	0.07% Max.

Other requirements were that the sources should be as near to Chittaranjan and the cost as low as possible. With these as our aim, sources were searched and the following selected for investigation—Rajmahal; Allahabad; Jabalpore; and Chirkunda. Search for other sources is still going on.

INVESTIGATION

(1) *Rajmahal* :—

Rajmahal is situated on the banks of the River Ganges on the Bengal-Bihar Border. The sand occurs as loose mass with high grade Kaolin to an extent of 10 to 15%. There is an overburden of grit and other materials of 10 to 15 feet. The thickness of the sand layer is as much as 100′—0″.

There are two sites at present where from the sand is being taken out. One of the quarries is being worked mainly for Kaolin. The area of this site is approximately 75 acres but the extensity of the deposits are not demarcated. Here quartz sand comes out as a by-product of washing the Kaolin. The sand is classified as under :—

1. Unwashed Ordinary Silica Sand.

TABLE No. 1

RAJMAHAL SAND

Sample No.	1	2	3	4	5	6	7	8	9	10	11	
Name of Sample	Sand Ordinary	Ordinary White	S & W Sand −30 Mesh	S & W Sand +30 Mesh	Sand Ordinary Off Colour	K. S. Sand	K. S. Sand No. 1	K. S. Sand No. 2	K. S. Sand No. 3	K. S. Sand No. 4	"Sand"	
Colour Before Wash	White	Ash Colour	Ash Colour	Ash Colour	Pinkish White	Yellow	White	Brownish Yellow	Brown	Deep Brown	Brownish White	
Colour After Wash	Do.	White	White	Greyish White	Greyish White	Yellowish White	White	Yellow	Yellow	Yellow	Greyish White	
AFA Clay Percent	3.30%	4.1%	1.30%	1.00%	5.20%	3.20%	1.50%	3.30%	5.60%	4.10%	3.60%	
B. S. Sieve No.	%	%	%	%	%	%	%	%	%	%	%	cum %
5	—	0.30	—	—	1.00	—	—	—	—	—	0.64	0.64
8	2.00	1.40	—	—	1.60	—	—	—	—	0.10	0.40	1.04
10	1.20	1.10	—	2.50	1.30	—	—	0.10	—	0.24	0.30	1.34
16	9.40	6.80	—	18.60	7.90	0.10	0.30	0.40	0.10	1.40	1.30	2.64
22	14.80	13.90	0.10	38.90	11.70	0.24	1.04	0.90	0.40	4.20	2.20	4.84
30	17.04	15.80	13.84	29.30	15.00	2.50	7.90	7.64	3.90	20.94	9.40	14.24
44	21.04	16.20	31.50	5.00	18.00	10.94	42.00	26.44	20.40	41.00	32.80	47.04
60	16.70	17.10	25.40	2.10	15.30	19.10	22.80	18.20	19.50	13.40	20.00	67.04
100	9.62	12.60	17.24	1.20	12.00	44.54	16.50	30.50	33.30	8.70	19.70	86.74
150	2.80	5.86	6.80	0.40	5.20	12.50	5.90	8.84	10.60	3.88	5.70	92.44
200	1.10	2.60	2.30	0.30	2.60	4.80	1.60	2.80	3.60	1.50	1.64	94.08
Pan	1.00	2.24	0.52	0.70	3.20	1.08	0.46	0.98	2.60	0.54	2.32	96.40
Grain Shape	Mainly Subangular	Subangular with few Angular Grains	Mainly Subangular	Mainly Subangular	Mainly Subangular	Mainly Subangular	Mainly Subangular	Mainly Subangular, few Grains Angular	Angular & Subangular	Mainly Subangular	Subangular to Round	

Chemical Analysis

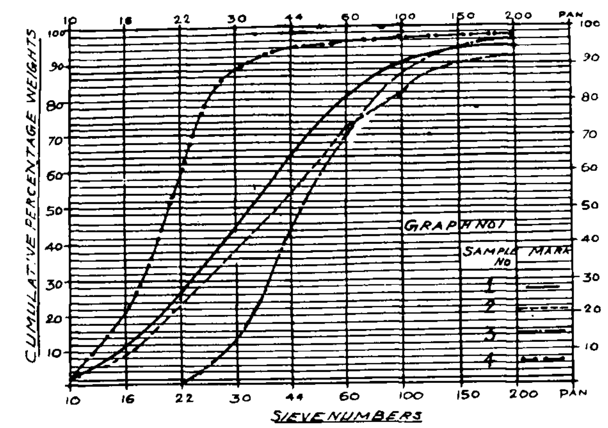
Sample No.	Loss on Ignition	SiO_2%	R_2O_3%	Fe_2O_3%	$(R_2O_3 - Fe_2O_3)$	CaO%	MgO%	Total
K.S.No. 2	0.28	97.50	1.12	0.08	1.08	1.12	0.08	100.10
K.S.No. 3	0.28	97.06	1.52	0.06	1.46	1.02	0.02	99.90

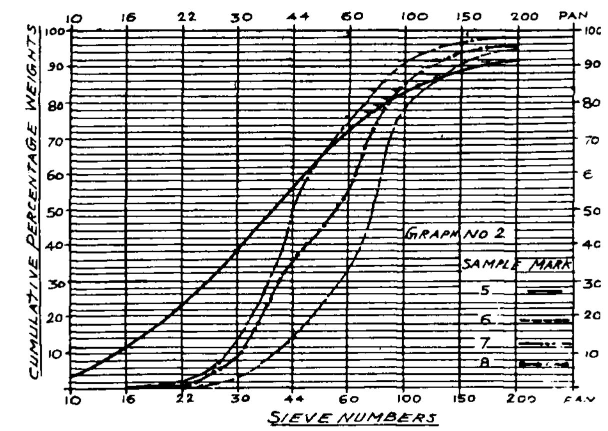
Sintering Temp. K.S.No. 2 & 3 .. Over 3000°F.

2. Washed and Screened (−) 30 mesh sand.
3. Washed and Screened (+) 30 mesh sand.
4. Ordinary off colour sand.

The chemical and mechanical analysis of the samples collected from this area is given in table No. 1 & cumulative curves are shown in Graph No. 1 & 2. The off-colour sand has not been analysed but the silica content is much lower. It can be useful in grey iron foundry.

RAJMAHAL SAND CUMULATIVE CURVES

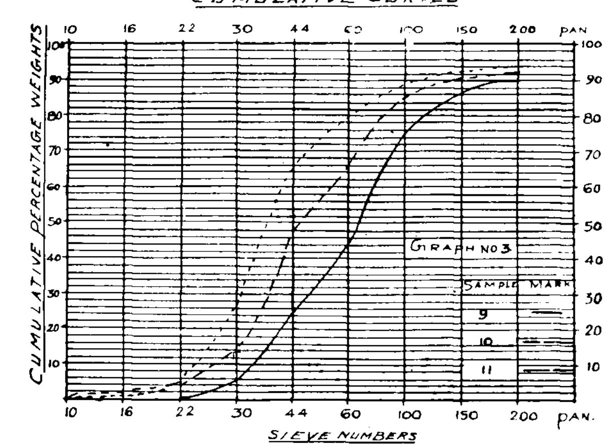




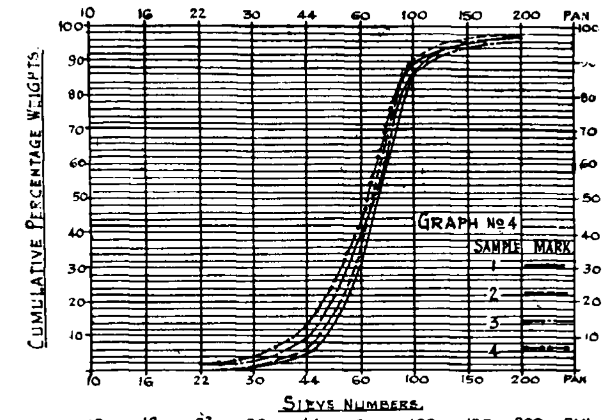
The second site which is called Kanaisthan is about 2 miles away from this source. The area of working is about 60 acres. The exact availability has not been surveyed. The colour of sand here varies from seam to seam. Four samples representing each seam have been tested and reports are given in table No. 1 & Graph No. 1 to 3.

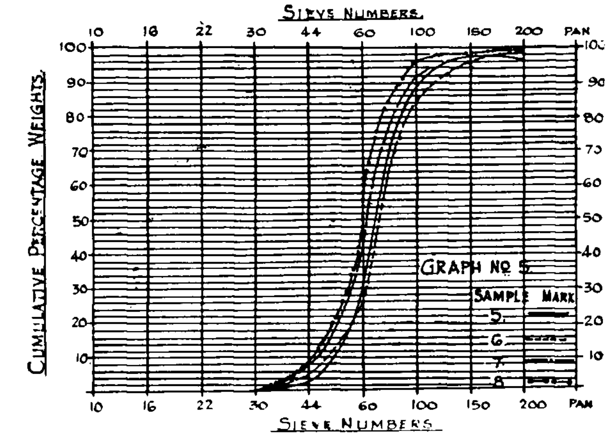
The sand from this area has a grain shape subangular to round. The edges are more rounded and the sand is almost clay-free. This sand is considered much superior to the washings from Kaolin for use in Steel Foundry.

RAJMAHAL SAND CUMULATIVE CURVES



ALLAHABAD SAND CUMULATIVE CURVES.





(2) *Allahabad*:

Around Shankargarh area of Allahabad District, there are extensive sand-stone belts of which we have examined three main sources. A good number of these places have been visited and at each of these places sand exists as a bonded sand stone which could be crushed to sand. The mass varies from loose aggregate to a fairly hard rock. The rocks are on the

ALLAHABAD SAND

TABLE No. 2

Sample. Ref. No.	1	2	3	4	5	6	7	8
Mark on Sample		Bargarh 1	Bargarh 2	Jemhora West 1.	Jemhora Stone	Jemhor West Loose	Jemhor West 2.	Jemhora East
Colour After Wash.	Greyish white				Not Washed			
Afa Clay %	2. 2%				Not Found Out			
MECHANICAL GRADINGS								
B. S. Sieve No.	% Re	% Re	% Re	% Re	% Re	% Re	% Re	% Re
16	—	—	—	—	—	—	—	—
22	0.20	0.16	0.80	0.34	—	0.14	0.34	0.24
30	0.80	1.24	2.16	3.46	0.70	1.34	1.34	0.90
44	4.40	5.54	6.70	9.34	2.06	4.40	8.00	8.86
60	25.90	25.76	29.98	17.82	29.00	21.70	33.76	35.56
100	57.50	57.96	46.50	48.80	56.98	58.14	47.84	39.74
150	6.10	7.06	8.84	6.36	8.36	11.44	6.04	12.40
200	0.90	0.90	1.74	1.77	0.64	1.00	1.30	2.40
200	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest

Micro Examination

Sample 1 Mainly Subangular.

Sintering Temp.

Sample No. 1 Above 3000°F.

Chemical Analysis.

Sample No. 1	Loss on Ignition	SIO_2	R_2O_3	Fe_2O_3	$(R2O_3-Fe_2O_3)$	CaO	MgO	Total
	0.15	98.05	0.92	0.04	0.88	1.12	0.03	100.27

TABLE No. 3

ALLAHABAD SAND

Sample Ref. Nos.	9	20	13	21	16	11	14	17	23
Name of Samples	Silica Gadwa White	Silica Gadwa Yellow	Silica Chirodi Yellow	Silica Chirodi White	Silica Killa White	Silica Killa Yellow	Silica Bandhana White	Silica Jemhora White	Silica Gotaiya White
Colour before wash	Light Yellowish White	Yellow	Yellow	Light Yellow	Yellowish white	Brownish White	White	White	White
Colour after wash	Greyish White	Yellowish	Yellowish White	Brownish White	Brownish White	Brownish White	Milky White	Milky White	Milky White
A.F.A. Clay percent	1.86%	1.2%	2.4%	3.1%	0.3%	1.2%	3.5%	1.2%	2.3%
B. S. Sieve No.	% Retained	%	%	%	%	%	%	%	%
5	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
16	—	—	—	—	0.02	—	—	—	—
22	0.30	—	4.00	2.50	0,04	1.00	0.02	1.20	0.30
30	1.10	0.20	30.10	18.90	3.64	19.12	00.20	4.20	1.84
44	6.30	1.40	20.30	22.70	22.24	32.80	1.24	26.80	11.14
60	30.28	33.30	18.20	28.00	28.80	14.20	27.30	37.50	32.74
100	50.00	53.50	15.80	19.00	27.74	17.30	55.20	22.10	41.70
150	8.40	7.30	6.70	4.50	14.98	10.70	7.70	2.80	8.14
200	0.50	1.70	1.04	1.30	1.94	1.30	2.50	1.60	1.01
Pan	1.26	1.40	1.46	NIL	0.30	2.38	2.54	2.60	0.83
Grain Shape	Mainly sub angular with few round grains	Mainly consists of two sizes. Smaller grains subangular Bigger grains round	Same as Sample No. 8 Bigger grains are not so much round	Subangular to round	Same as in Sample No. 8 & 9	Same as in sample No. 13	Mainly subangular with more rounded edges	Mainly subangular to round	Subangular to round

TABLE No. 4

ALLAHABAD SAND

Sample Ref. Nos.	10	12	15	18	19	22
"Marks on Sample"	Gadwa White	Killa Yellow	Bandhana	Jemhora White	Jemhora Yellow	Chirodi White
	(2nd Sample)	(2nd Sample)	(2nd Sample)	(2nd Sample)		
B. S. Sieve Nos.	% Retained	% Retained	% Retained	% Retained	% Retained	% Retained
22	1.40	2.94	0.14	1.04	0.8	3.84
30	0.90	28.24	1.04	6.10	3.70	20.94
44	5.76	36.10	11.80	25.14	12.80	33.30
60	36.00	17.04	35.00	27.34	32.60	24.56
100	46.80	9.74	37.26	28.04	38.00	9.50
150	6.10	0.96	9.60	9.40	9.20	2.40
200	1.00	0.28	1.74	1.24	1.36	0.24

Chemical Analysis

Sample No.	Lobson Ignition	SIO_2	R_2O_3	Fe_2O_3	(R_2O_3–Fe_2O_3)	CaO	MgO	Total
9 Gadwa White	0.40	98.14	1.16	0.10	1.06	0.42	0.03	100.15
14 Bandhana White	0.79	96.88	1.32	0.03	1.29	0.72	0.03	99.74
20 Gadwa Yellow	0.31	97.72	0.96	0.06	0.90	1.02	0.15	100.16
23 Gotaiya White	0.20	98.10	1.02	0.15	0.87	0.74	0.26	100.32

Sintering Temperature

Sample No. 9, 14, 20, 23 were tested & no sign of sintering was observed at 3000°F (1660°F).

TABLE No. 5

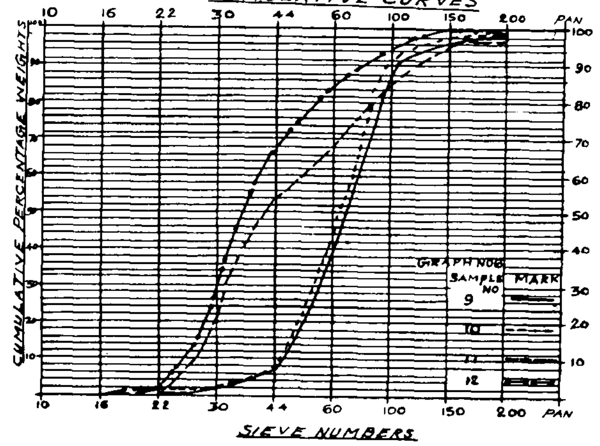
ALLAHABAD SAND

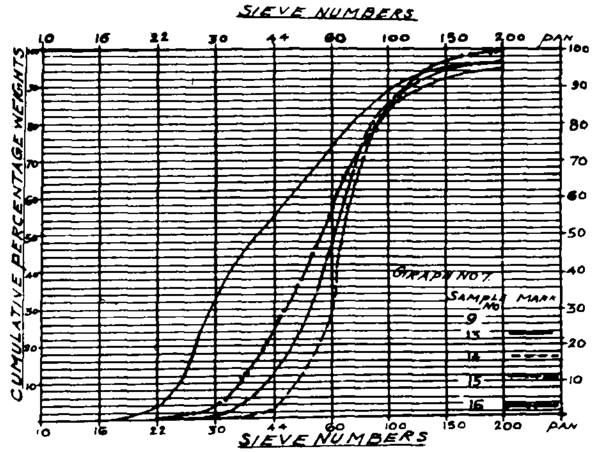
Sample Ref. Nos.	24	26	27	25	28	29	30	31	32
Name of Samples	Silica Sand Yellow	Silica Sand White	Silica Sand White	Silica Sand Yellow	Stone No. 1	Stone No. 2	Stone No. 3	Stone No. 4	Stone No. 5
Colour Before Wash	Deep Yellow	Greyish White	White	Yellow	Pink	Pink	Pinkish White	Yellow	Pinkish White
Colour After Wash	Yellow	White	White	Yellowish	Pinkish White	White	White	Yellowish	White
A.F.A. Clay percent	1.6%	1.0%	1.3%	0.4%	3.0%	2.64%	2.7%	3.16%	2.3%
B.S. Sieve No.	%	%	%	%	%	%	%	%	%
5	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
16	—	0.10	—	—	0.08	—	—	—	—
22	1.50	0.60	0.40	1.20	0.36	0.10	0.06	—	0.10
30	23.14	4.10	0.90	12.50	2.60	1.20	0.80	0.30	2.40
44	32.80	17.50	4.90	27.10	17.96	14.44	11.40	2.40	19.00
60	23.64	28.20	16.84	33.60	30.36	40.70	37.70	13.54	37.50
100	12.50	34.50	35.30	24.00	36.00	23.80	38.64	51.14	31.50
150	2.90	10.80	22.80	0.60	5.12	11.40	5.24	24.60	4.60
200	0.70	1.80	10.00	0.60	3.08	2.90	1.54	3.60	1.34
Pan	1.22	1.40	7.56	Nil	1.44	2.82	1.92	1.26	1.26
Grain Shape	Subangular to round	Subangular to round	Subangular	Subangular to round	Mostly round	Subangular to round more or less uniform gradation	Subangular	Subangular uniform gradation	Subangular to round
Sintering Temperature					Over 3000°F	Over 3000°F	Over 3000°F	Over 3000°F	Over 3000°F

Chemical Analysis

Sr. No. of Samples	Loss on Ignition	SiO_2%	R2O$_3$%	Fe_2O_3%	(R_2O_3–Fe_2O_3)	CaO%	MgO%	Total
26	0.27	98.24	1.12	0.02	1.10	0.76	0.03	100.42
27	0.50	97.72	1.76	0.10	1.66	0.42	Trace	100.40
30	0.65	97.62	0.72	0.02	0.70	0.68	0.40	100.07
29	0.44	96.74	1.36	0.02	1.34	1.12	0.33	99.99
31	0.39	96.50	1.62	0.12	1.50	1.12	0.02	99.65

ALLAHABAD SAND
CUMULATIVE CURVES





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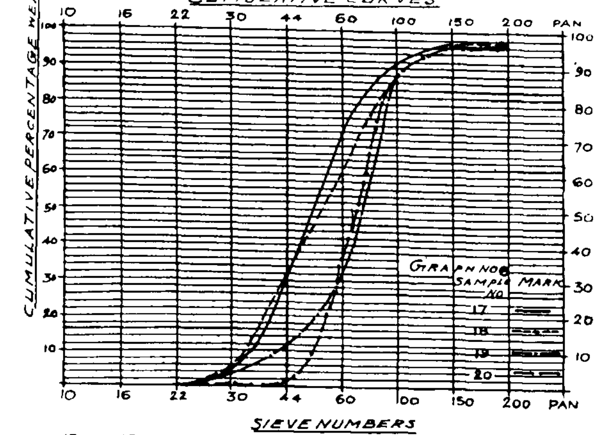
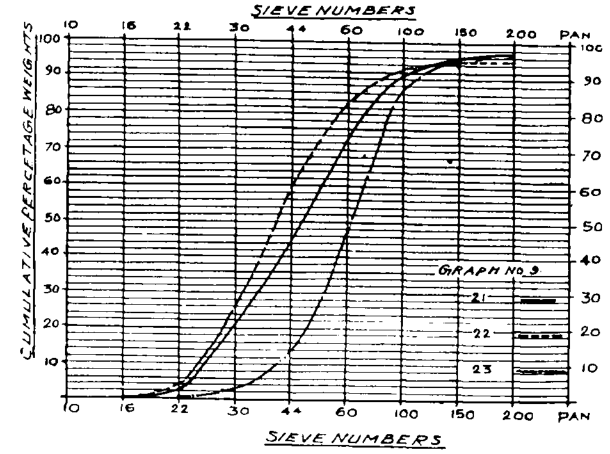
CUMULATIVE CURVES





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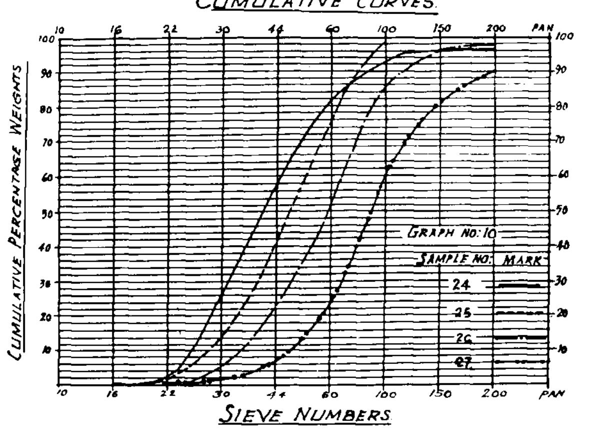
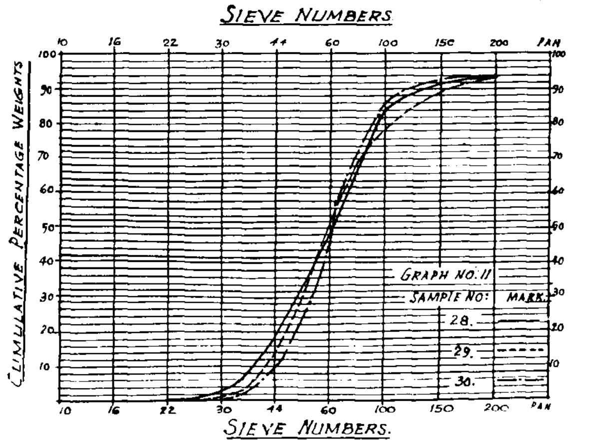
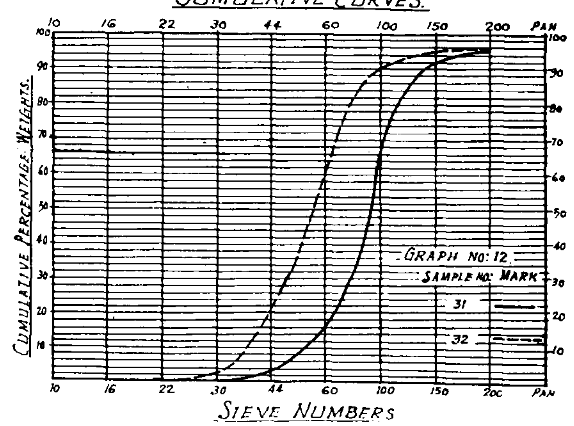
CUMULATIVE CURVES





ALLAHABAD SAND.
CUMULATIVE CURVES.



surface of the ground but at certain places as much as 15′—0″ of earth has to be removed before the sand-stone can be taken out. The sand stone seems to have a depth between 50′—0″ to 200′—0″. The colour of the sand varies from seam to seam. In the case of hard aggregates the crushed sand shows certain amount of breakage of grains resulting in sharp angular sand.

The physical, chemical & mechanical test-results of some of these sands are tabulated in table Nos. 2, 3, 4 & 5 and the cumulative curve in Graph No. 4 to 12.

There are extensive deposits of sand-stone near Bargarh Railway Station, which is about 12 miles away from Shankargarh. These deposits appear to be very similar to the Shankargarh sands. There is no record of any detailed survey on the extensity of these deposits. The samples collected from various sources at these places show similar results as those of Shankargarh. Some of the reports are given in the table No. 2 and cumulative curve is Graph No. 4.

(3) *Jabalpore:*

Jabalpore sand can broadly be classified into (i) sand stones and (ii) clay washings.

Sand Stones :— In general it can be said that sand stones obtained are all soft in nature and can be crushed with slight hammering. Considerable clay have been found in all the samples. Some samples have shown even upto 10% clay. But the clay was found easily washable. The variation of colour is also considerable as can be seen from the table No. 6. The availability of these deposits is not determined. A considerable deposit of soft sand stone is found near the yard of Jabalpore Railway Station (Central Railway). The samples from different areas were collected and examined in the laboratory.

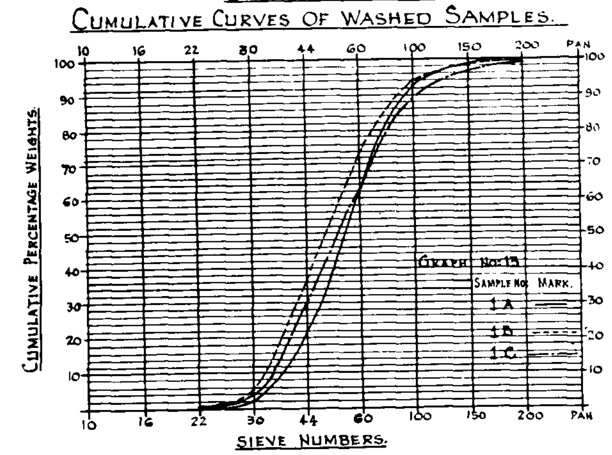
The silica content of these washed samples was found to be as around 95.5 with a variation as given in table No. 6. The R2O4 value is rather on higher side. Fe2O3 was found to be 0.9% max.

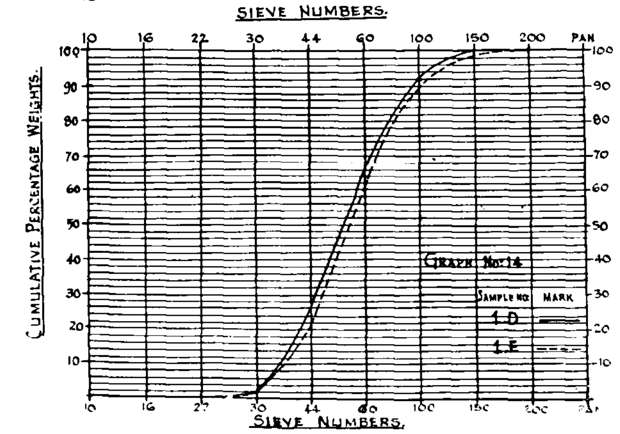
The shape of the grain and its sintering temperature were all favourable. The shape is subangular to round and the washed sample was found to stand upto 3000°F without any sign of fusion. The grain distribution is also satisfactory and is comparable with other deposits.

The cumulative curves of the samples are shown in Graph Nos. 13 to 17.

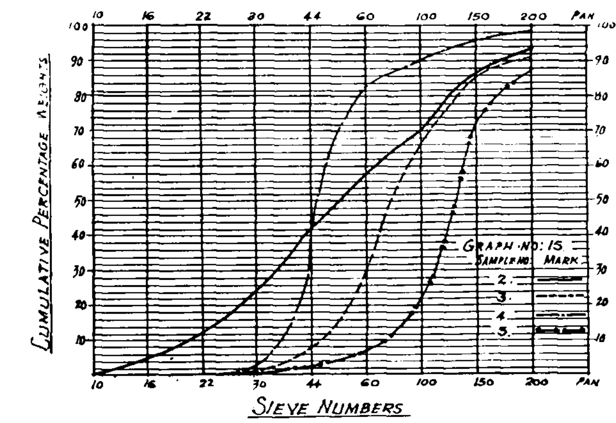
(ii) *Sand from Washings* :— The second category of sand is obtained along with fireclay and by washing,

JABALPORE SAND
CUMULATIVE CURVES OF WASHED SAMPLES.





JABALPORE SAND
CUMULATIVE CURVES OF UNWASHED SAMPLES.



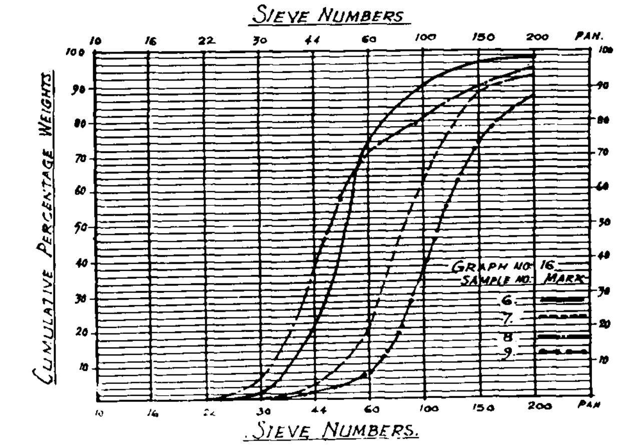


TABLE NO. 6.

SILICA SAND (JABALPORE)

Place from Where Sampled	JABALPORE RAILWAY YARD														Sand from washings
Sample Sl. No.	1A	1B	1C	1D	1E	2	3	4	5	6	7	8	9	10	12
Details of Collection	Obtained from the same pit and from different heights					From different pits									
Colour of Sample	Greyish Colour					Brown	Dark Brown	Greyish White	Pinkish White	White	Yellowish White	Greyish White	Greyish Pink	Dark Brown	Grey
AFA Clay %	4.5%	8.42%	7.25%	8.20%	9.90%	Unwashed									7.2%
Mechanical Gradings															
Bss Sieve No.	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret	% Ret
16						4.68								0.50	13.84
22						8.20	0.10	0.10				0.60		3.54	19.50
30	2.00	4.40	2.40	1.40	1.60	12.10	0.84	2.92	1.02	0.36	0.60	4.90	0.68	7.90	19.94
44	20.00	33.20	27.00	22.46	20.40	17.68	6.80	41.10	1.92	21.46	3.20	33.18	1.52	20.00	16.16
60	40.00	36.40	35 00	44.10	36.40	15.50	24.80	37.70	3.86	53.90	15.60	31.76	4.74	51.90	8.84
100	31.00	20.00	24 40	26.20	30.00	11.44	34.34	7.30	16.96	15.44	42.80	9.84	28.50	9.10	7.24
150	6.20	4 40	8.40	8.00	9 50	17.00	18.00	6.00	48.20	5.40	27.60	10.50	40.30	3.20	3.84
200	0.80	1.20	1.80	1 00	2.00	5.10	5.14	1.94	15.10	1.90	5.30	3.40	12.30	0.80	1.84

	1A to 1E	2 to 10	12
Chemical Analysis	Representative of 1A to 1E SiO_2 95.82% R_2O_3 3.16% CaO 0.44% MgO 0.18% Fe_2O_3 0.35% Loss 0.42%	$(R_2O_3 - Fe_2O_3) = 2.81$ Representative of All SiO_2 95.5% Fe_2O_3 0.90% $(R_2O_3Fe_2O_3)$ 3.1% CaO Traces MgO 0.3 Loss 0.18	Not done
Sintering Temp	Above 3000°F	Not Done	Not done
Shape	Subangular to Round	Subangular to Round	Angular to Subangular

TABLE NO. 7

CHIRKUNDA DHANBAD

Name of Pit	Baliyd		Chirkunda
Mark of Sample	Baliyd Coarse	Baliyd Fine	Chirkunda
Colour Before Wash	Greyish White	Greyish White	Milky White
Colour After Wash	Greyish White	Greyish White	Milky White
AFA Clay Content	6.3%	8.4%	9.7%

Particulars of Collection — Collected Personally as Lumps

Preparation of Samples — Lumps were broken into pieces by Lighter Hammering & then Hand Pressing

Mechanical Gradings	1 Washed % Retained	2 Washed % Retained	3 Unwashed % Retained	4 % Retained
16	0.14	Nil	0.10	Nil
22	0.64	0.06	0.64	0.38
30	2.24	0.94	1.86	2.50
44	27.36	12.94	16.90	8.06
60	32.56	34.00	38.10	14.40
100	18.24	29.16	24.94	18.82
150	7.30	9.50	8.90	22.36
200	2.42	2.90	2.44	11.30
300	0.78	Rest	0.70	Rest
Pan	Rest	Rest	Rest	Rest

Chemical Analysis (Finer Sand)	Loss on Igni	SiO_2	$R2O_3$	Fe_2O_3	$(R_2O_3 - Fe_2O_3)$	CaO	MgO	Total
	0.20	97.04	1.30	0.32	0.98	0.83	0.48	99.85

Microscopic Examination

(A) Fine — Round to Subangular

(B) Coarse — Round to Subangular

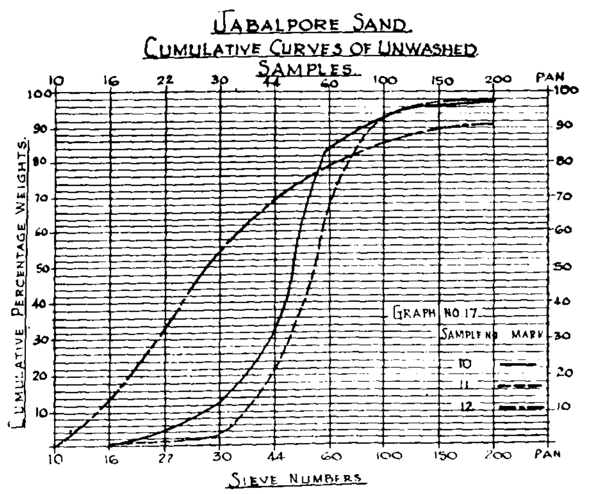
Sintering Temp.

The Sample of Baliyad was tested & found to pass Sintering test upto 3000°F.

the sand is separated. The shape is more angular and grain distribution widely varied (see Graph No, 17 and table No. 6).

(4) *Chirkunda*

There are two deposits of silica sands at Chirkunda about three miles from Kumardhubi. The area belongs

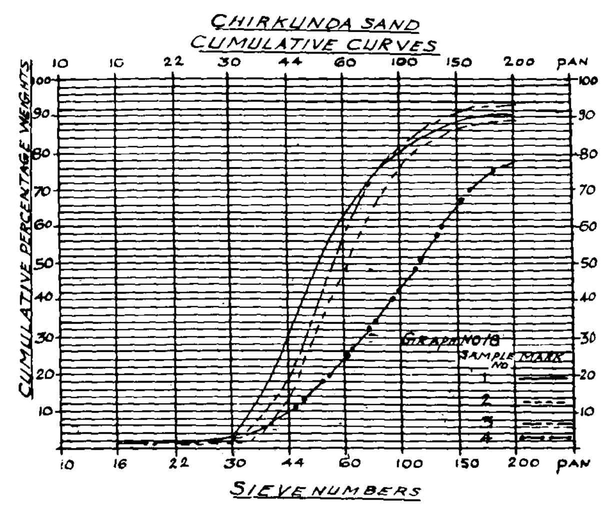


to Dhanbad District and is very near Barkar River and the Grand Chord Railway line. The deposits can be identified as Chirkunda and Baliyd sands.

(i) *Chirkunda Sand*—The sand deposit is very near the Grand Chord Railway line and Barakar River. The deposits consist of alternate layers of soft sand-stone and fire-clay. The single seam of sand-stone varies from 3½ feet to 5′—0″. The thickness of fire-clay seam varies from 1′—0″ to 1′—6″. The sand-stone from Chirkunda is very soft and contains considerable clay to an extent of 10%. The fines in washed sand are very high. The details of the tests are given in the table No. 7. The cumulative curve is shown in Graph No. 18.

(ii) *Baliyd Sand*—The deposits are in the form of sand stone. The locality is also near Barakar River and towards Maithon. The deposits appear to extend over about 300 acres of land. However they are not continuous in nature. The over-burden varies upto 3′—0″. The stones are considerably hard when compared with other deposits. The sand samples were collected from different pits to study the variations, the report of the chemical analysis and mechanical grading is given in table No. 7. The cumulative curve is shown in Graph No. 13.

The shape of the grain sand is subangular to round, and the grading is considered satisfactory. The clay



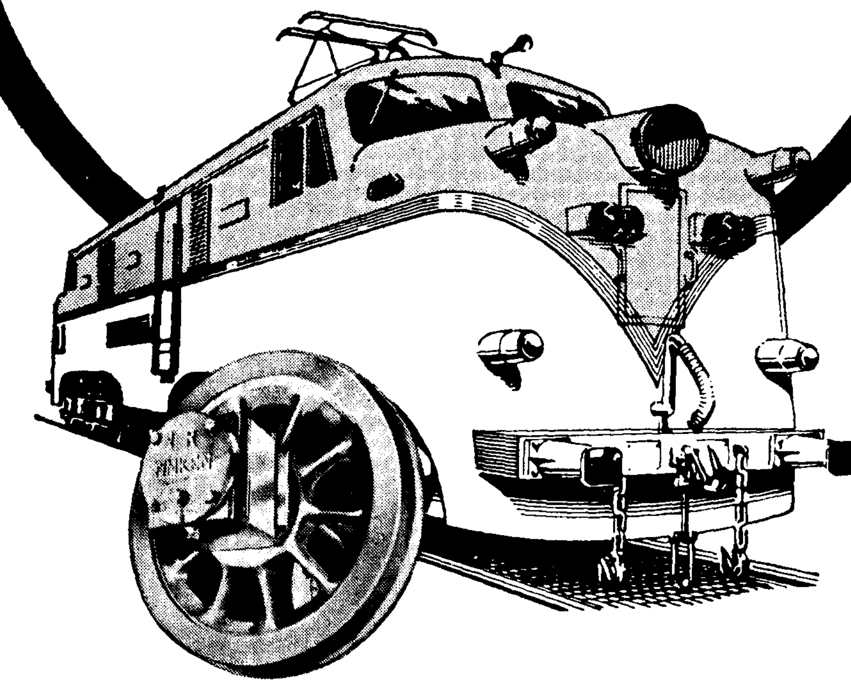
content is about 6—7%. The sand stands sintering test upto 3000°F.

CONCLUSIONS

Silica sands of medium coarse, medium fine and fine grain size are available around Chittaranjan. Among them Rajmahal, Allahabad, Chirkunda and Jabalpur are the important sources in the order mentioned. The Rajmahal sands are generally coarser than Allahabad sands. Some of the Allahabad sands are quite fine.

All the sands have comparably low clay which is easily washable. The chemical, mechanical and thermal properties are quite satisfactory. The Allahabad sands are more consistent as regards grain distribution and shape are concerned with the result the yield on washing and grading will be quite high.

It was not possible to estimate quantitatively the availability of the sand at these deposits. There are no comprehensive survey reports, but the deposits are quite extensive. With the increase in demand of the sand for the foundries, a detailed prospecting of the deposits to examine the extensity of the deposits, the variations in properties etc. is necessary. Possibility of setting up a large washery for washing and grading at source should also be examined.



Recent Trends in Loco Painting

By S. Ramanujam
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PAINTING as practised today is not only for decoration but also for protection and greater safety. In the beginning, the emphasis was not on durability but on aesthetic appeal. Eversince Bessemer made public his process which reduced the price of steel to about a fifth of its former cost and made possible its extensive use in industry, the protective aspect gained importance. Till recently, however, deterioration of steel by corrosion was more or less generally accepted as an everyday fact and the engineer's attitude was that rusted material could be easily replaced when necessary. With the increasing scarcity of steel and its soaring price the world has increasingly become corrosion conscious. Efforts to effect economy in steel by the use of light gauge sections where the margin of safety is small make it essential that corrosion must be prevented at all costs. This has at present forced engineers to regard painting as an aspect of construction and maintenance which has to be taken into account in the design stage in the same way as other operating conditions like pressure and temperature. It can no more be regarded as the last operation in construction which can be relegated to the painter foreman.

The corrosion troubles encountered in Indian Railways arise not only from the extremely diverse and in many cases exacting requirements but also from the rigours of a tropical climate varying from place to place and representing all types, marine, industrial or humid atmospheres. In the case of corrosion primarily involving moisture and oxygen, painting is the easiest, the most economical and hence a widely used method. It may be noted that during 1957—58 the Indian Railways consumed about 2.12 crores of painter's stores consisting of drying oils, paints, varnishes, enamels, thinners etc.

PAINT REQUIREMENTS IN RAILWAYS

Protective measures which are adequate for industrial atmospheres are often insufficient for railway purposes. Modern railway requirements in industrial paints are extremely diverse and in many cases exacting. Perhaps, in no other place in industry are the demands on paint quite comparable to that put on railway rolling stock. They are out of doors all the year round, subject to continuous vibration and all weather conditions. The coatings are in a brief space of time subjected to wide ranges in climatic conditions, to intense cold and heat, moist heat and cold and temperature fluctuations which may be as great as 50°C during coach movements in 24 hours. They have to withstand alkaline desert dust, the salt spray from the sea and the washing action of rain during the monsoon whilst being exposed all the time to the acid gases from engine smoke or to the blasting action of cinder and sand. In addition, they have to stand up to the strong cleaning required to remove firmly adhering dirt films which may require hard scrubbing for its removal. The painted surface must withstand all these conditions and still present a good appearance for at least two years of service.

Owing to the scouring action of sand raised at high speed, the toughness of the vehicle is far more important in railway work than in the case of most stationary land structures. Lacquer which gives remarkable service in automobiles is found to chip off in spots on corner posts, vestibules ends and rivets. Exterior painting of railway coaches is not only for rust protection but also for obtaining a smooth and attractive finish. If the problem of preservation only were involved as in the case of wagons or bridges, a much fewer number of operations would naturally be involved. As appearance is also important, much preparatory work is required. The interior finishes for lower class coaches require paints that will resist perspiration, moist heat and hair oil of passenger. Since drying oils do not stand repeated washing, and cleaning, the modern tendency is the use of varnish and enamels. Tanks carrying petrol require paints which are good reflectors of light and heat rays. Surfaces under the wood sleepers of an open deck bridge corrode easily, as these parts are not accessible for painting and moisture getting between the sleeper and steel does not easily dry up. To prevent this, a paint is required which will not harden or deteriorate with age, but will remain permanently plastic and carry heavy pressure under the sleepers. Again, bridges have seldom time to dry up and are subject to the corrosive effects of engine smoke and paints have often to be applied on damp surfaces. For gangways of coaching stock, fire-resisting paints are required to

reduce fire hazards. The paint applied to underframes and running gear has to withstand abrasion from flying particles stirred up by the velocity of the train but not sunlight. Hence, the toughness of the vehicle is far more important here than in the case of stationary land structures.

The surface coatings for steam locomotives should not only withstand relatively high heat but also be resistant to acids and alkaline water including repeated washing with soaps. In addition, the finish of a locomotive must weather well and be oil resistant. In India, the seasonal variations in weather from brilliant sunshine with its accelerating effect on the oxidation of the binder to the drenching rain of the monsoon operating conjointly with daily fluctuations of temperature provide a supreme test for paint.

OIL VS. SYNTHETIC PAINTS

The traditional paints based on linseed oil have many disadvantages and have no place in the modern mass production methods or in severe corrosion conditions. A major deficiency of linseed oil as a paint vehicle is the formation of polymers by oxygen links (HC-O-CH) which are less stable than carbon—carbon links. HC-CH. Another effect of the addition of oxygen is the increase in polarity thereby rendering the coating permeable to polar materials like water which lessens resistance to prolonged attack by water and chemicals. It would, therefore, be desirable to produce a reasonable proportion of stable links in the liquid material so as to leave only a smaller degree of unsaturation for forming air dried films through less stable peroxide stimulated cross links. Such is the case with linseed stand oil where a high proportion of polymers involving a stable carbon—carbon link is formed by heat polymerisation of unsaturated fatty acids. They are therefore not available for the subsequent formation of the less stable peroxide stimulated links during drying.

Further, as thermal decomposition generally occurs at exposures of 350°F or higher for several hours, resulting in discolouration, loss of gloss and loss of film integrity, straight oil paints are not satisfactory for parts of locomotives such as boiler clothing plates and smokebox which reach temperatures approaching 410°F. These require vehicles with minimum oxidising tendencies.

Synthetic finishes are associated with quick hard drying properties, excellent flow characteristics, high gloss and good gloss retention. There are two distinct types—phenolics and alkyds. The former are obtained by condensing phenol with formaldehyde whereby the various phenyl nuclei are joined together by carbon linkages. These are ideal under conditions of water immersion and severe chemical attack. For outdoor exposure, the 'alkyds' are however, superior. These are made from resins derived by esterification of poly-hydric alcohols with poly-basic acids. Though the alkyds are oil acids esterified with glycerol and have the basic glyceride structure characteristic of straight drying oils, co-esterification with phthalic acid results in the linking of a large proportion of the glyceride units by phthalic acid groups instead of poly meric fatty acids as is the case with oil films. As the phthalate links are already formed before drying commences, only a few links remain to be formed. The alkyd films, therefore, dry rapidly as compared with oil. Further, these films would be much more cross-linked than a dried oil film and hence, are less likely to suffer decomposition by oxidation.

In the tropics, exterior paints having phenolic resins lose gloss rapidly and this type of paint has less resistance to weather than an oil paint. The alkyd types possess superior adhesion though inferior to phenolic resins as regards resistance to moisture and mild alkali. They are superior to either the pure phenolics or mixtures of alkyds and phenolics as regards checking and chalking. Alkyd vehicles are specially valuable when high gloss, weather resistance colour retention, levelling and non-yellowing are the primary requirements. This is specially so in the case of black enamels which due to the low content of pigment retains gloss like the varnish medium even after 18 months as compared to red oxide where the gloss is lost within 4 months.

LOCOMOTIVES TYPES

It may be noted that since 1940, the U.S.A. have changed over to diesel-electric traction. The hauling capacity of a diesel loco is much better at low speeds and the starting pull is over double that of a steam loco of equal horse-power rating. Therefore, for shunting purposes particularly the diesel loco is most effective. Even for main line service the above factors enable greater availability of diesel locos. About 35 to 70 diesel electric locos have been found to do the work of 100 steam locos, depending upon utilisation of the service availability. Operational savings on account of fuel and better availability have already paid for the original cost of investment on diesel within a period of 6 to 8 years or so. In the case of shunting locos, diesels appear to have shown even better financial returns by paying for themselves within 3 to 5 years. This excellent financial result in favour of diesel is mainly due to very low cost of oil obtainable in plenty in America as compared to coal cost viz. 6 cents per U.S. gallon against 6 dollars per short ton of coal.

As all railways in U.S.A. are operated by private companies electrification of the railways in U.S.A. does not offer economic advantages as traffic between important centres is often split up over several lines operated by competing companies. The diesel locomotive has the advantage that it dispenses with the costly overhead equipment necessary with electrification. The entire capital outlay is expended in locomotives which are movable assets, capable of being shifted from one network to another. By 1950, over 60 per cent of the shunting locomotives in the states were diesel powered and no new orders were placed for steam locomotives.

On the contrary, in Europe, petroleum requires to be imported and is expensive. Hydro-electric or thermal power is available at reasonable rates. Finally, most of the European railways are nationalised undertakings. As diesel locos are more prone to breakdown and will take longer to overhaul, a relatively larger number of units would be necessary for dieselisation. The cost of repairs and maintenance of diesel locomotives would be considerably higher than that for electrical locomotives. These factors have influenced their programme of electrification.

British Railways carry more than double the number carried on the Class I Railroads of the U.S.A. While the steam locomotive will continue, under the 1500 m modernisation plan launched in 1955, it is proposed to relay in future mainly on diesel and electric traction. As a result of this, the building of new steam locomotives has virtually ceased. It has been accepted that for the main routes, electric traction is the ideal method since the traffic density is adequate to cover the annual charges on the fixed equipment. This being, however, of a long term character owing to considerable work being necessary for signalling telecommunications, the British Transport Commission decided that there was room for a complementary diesel traction programme since many of the advantages of electric traction were attainable with the diesel engine. In a big effort to side track passenger business from the road services to the railway, a £2,000,000 programme for the development of 1,200 light weight diesel passenger services has been initiated.

CONDITIONS IN INDIA

In India too, the Ministry of Railways have taken a bold decision to replace steam with electric traction to the maximum extent possible within their financial and technical man-power resources. Though the first electric train ran from Bombay to Kurla on February 3, 1925 and the Madras Beach—Tambaram section was electrified in 1931, India had only 246 route miles and 579 track miles electrified up to the end of the First Plan mainly to carry suburban traffic. There are, however, proposals for second plan electrification schemes totalling 1353 route miles estimated to cost over Rs. 100 crores. These cover areas where steam traction could not cope up with the increase in coal and steel traffic. 110 A.C. locos have already been ordered in 1957. The progress with the newer types of motive power can be seen from the following available data

	1950		1959		
	Steam	Diesel & Electric	Steam	Diesel	Electric.
U.S.A.	25,640	14,963	1,350	27,575	556
U.K.	19,884	108	14,457	1,800	85
France	14,274	913	5,474	1,455	1489
India	7,918	—	10,120	181	92

LOCO PAINTING PRACTICE IN THE U.S.A.

In the early days, oil base paints were exclusively used on all railway equipment. However, the requirements of resistance to cleaning compounds and abrasion has brought about the almost universal use of high grade oleoresinous and alkyd enamels which have not the undesirable characteristics of dirt retention possessed by oil base paints.

Steam locomotives : Steam locomotives are washed frequently and boiler water treated with alkalies may come into contact with the finish. The usual finishing system therefore consists of one coat of primer of a corrosion inhibitive type like red-lead or zinc chromate and two coats of enamel based on an oleoresinous phenolic spar varnish and a maximum of 5% carbon black. Lately, long oil alkyd finishes with slow evaporating solvents have been used on the basis that their better durability justifies the slightly higher cost. They are easily brushable, dry hard overnight and have excellent gloss retention. But they are not as highly resistant to alkalies as the best phenolic varnishes. The

inside of tender tanks is not usually painted as the boiler feed water is often treated with soda ash which attacks paint films. The outside of the boiler is painted with red lead or iron oxide before installing the insulation and the boiler jacket. In the past few years, this is giving place to heat resisting aluminium paints. The interior cab enamel is usually of a light green shade made from spar varnish having resistance to acids as well as repeated washings with mild cleansing solution. White lead paints are undesirable as they discolour on exposure to sulphurous gases from engine smoke.

Diesel and Electric locomotives : Electric and diesel electric locomotives however do not require heat resisting paints and usually are not washed as frequently. A three coat system on an oleoresinous or alkyd varnish base is generally used. Where appearance is an important factor as in the case of the new streamlined locomotives, the following procedure is adopted. First, a coat of primer is applied and allowed to dry 6—8 hours. Then a heavy coat or a double wet-on-wet coat of surfacer is applied. When dry (about 8 hours), low spots are puttied and glazed. After drying, the whole surface is wet sanded and wiped down or dusted. Then two coats of oleoresinous or alkyd varnish enamel are applied at an interval of 24 hours.

The practice in British Railways : Though from the point of view of durability, it would be ideal to remove millscale and rust by shot blasting as is practised in America and the continent or at least get them in a pickled condition or set up an automatic plant to shot blast the exterior, it has not been possible at present to do either of these owing to the limited shop accommodation. Only a superficial rubbing with emery with or without white spirit is given. Further, though improved efficiency in painting demands elimination of brush application with its extravagant employment of man-power, brush application is still continued due to the congestion in shops, where other trades have to work in the vicinity of the painting operations. Spray paint is, therefore, not practicable since it requires ventilated spaces.

STEAM LOCOS PRIOR TO NATIONALISATION

Prior to nationalisation, oil base paints were used.

For instance in the code of practice for loco painting issued in February, 1949, the exterior surface of clothing sheets and boiler was to be scoured with carborundum or emery wheel scraps and white spirit followed by one coat of primer. This contained 50—55% pigment (consisting of 88 parts red oxide, 10 parts aluminium powder and 2 parts zinc oxide) in a medium consisting of equal parts of linseed oil and mixing varnish with a maximum of 25% volatiles. This is now covered by B.R. 30/1. One coat of lead colour undercoat was then applied which had 50 lb. of zinc white composite pigment in oil, 25 lb. black in oil, about 20 lb. turpentine, 10 lb. dark gold size and 6 lb. liquid drier. After facing down with sand paper the next day, one coat of black paint was applied consisting of 23 lb. light gold size, 8—12 lb. turpentine and 78 lb. drop black in turpentine (obtained by heating in closed crucibles for a long time bones and residues from glue factories). This was followed by a coat of exterior finishing varnish. For front of tender one coat of the above locomotive black paint was given followed by one coat of finishing black enamel. For the bottom portions of cab interior, two coats of loco black were given followed by two coats of exterior finishing varnish.

The interior of cab roof was given 2 coats of white paint consisting of about 6 lb. mixing varnish, 12—16 lb. turpentine, 6 oz. ultramarine blue, 12 lb. paste driers and 78 lb. of zinc white composite pigment in oil (having 11—14% raw linseed oil, the remainder being a mixture lithophone and zinc oxide so as to contain not less than 33% zinc compounds of which at least one-fifth is zinc oxide).

The upper parts of the sides and front were given two coats of buff colour undercoat composed of 78 lbs. zinc white composite pigment in oil, 11 lb. paste driers, 8 lb. yellow ochre and 12—16 lb. turpentine. This was followed by a coat of graining colour consisting of 18 lb. yellow ochre in oil, 3 lb. burnt umber in oil, 12 lb. paste driers in oil, 24 lb. liquid driers and 24—28 lb. turpentine.

For foot plate, boiler front, smoke box, tender springs and boxes, frame outside, brake work and hand rails one coat of common black paint was given. This contained about 30 lbs. liquid drier, 22 lb. boiled linseed oil and 55 lb. black in oil (consisting of 35—40% raw linseed oil, the balance being pigment with 3 parts barytes and one part carbon black). For wheels, except where the metal is polished, one coat of glossy black paint was applied consisting of 60 lb. common black paint, 46 lb. finishing black enamel and 2—4 lb. liquid drier. For axles and frame inside, one coat of bauxite paint was applied. This consists of 8 lbs. boiled linseed oil, 6—10 lbs. white spirit, 2—4 lbs. liquid driers and 82 lb. bauxite residue in oil. The latter has about 10% paste drier, 30% boiled linseed oil and 60% of calcined and finely ground bauxite residue, passing 240 mesh, B.S. sieve. The bauxite residue should have water solubles below 1.5% and alkalinity below 0.3%.

Recent developments : Lately, medium oil alkyd resin enamels and varnish have been used for the finishing coat since their intrinsic durability is at least twice that of the oleo resinous finishes previously used. They have enhanced resistance to dirt and cleaning agents. To make them more heat resistant and somewhat quicker drying, they contain 26± 3 per cent phthalic anhydride as compared to the longer oil medium with 23 ± 3 per cent phthalic anhydride used for carriages. When the same alkyd was used for the primer and undercoat as well, the system showed poor impact resistance due to lack of balance between adhesion and cohesion arising from the high tensile strength of these media, and the strong contraction in drying and ageing. Hence an oleoresinous medium which has better wetting and adhesion due to the linseed oil medium and has better tolerance to poor surface condition was recommended for the primer.

Initially, a linseed oil based priming paint with alkyd resin undercoating, enamel and varnish, was used. Even the use of alkyd resin undercoating tended to give a film was liable so damage by impact. Resistance to impact is important since in course of time corrosion develops at the point of damage by impact which may be accidental or result from flying ballast when the train is travelling at speed. This will result in water entering behind the paint film and spreading corrosion. This was reduced by the introduction of oil based undercoatings while the spread of the corrosion from the damaged areas was prevented by ' phosphating '.

The present practice : In the code of practice for loco painting issued in 1956, the various components are to be wirebrushed free from loose scale and cleaned with white spirit. During and prior to assembly ; one coat of BR 30/2 primer to B.S.C. No. 445 is applied to boiler, engine frame (inside and outside), crank and straight axles of engine and Tender, Tender frame (inside and outside) and interior of boiler, cylinder and fire box clothing sheets. This had 55—65% pigment in a medium consisting of fossil resins or their esters in treated vegetable drying oils, with a maximum

of 25% volatiles and a hard drying time of 4-6 hours. The pigment comprised iron oxide, titanium white (TiO_2 15% min.), 2—4% zinc oxide and 10% suspending agent like chinaclay and/or asbestine.

The red oxide-aluminium prior to BR 30/1 the same as that used before nationalisation was used for the exterior or boiler, cylinder and firebox clothing sheets, exterior of tender, side tanks and coal bunker cab sides and roof, foot frame angle and wind deflector plates, smokebox, chimney, and steam pipe casing. No treatment was given to interior of tender, coal bunker and side tanks. For engine frame (inside and outside), wheels, straight axles, brake work, foot plate (platform round engine), tender frame (inside), front of tender, a coal of general purpose black paint to BR 30/5 was applied. This had 25—30% pigment in a medium of fossil resins or their esters in treated vegetable drying oils with a maximum of 25% volatiles, the hard drying time being 4—6 hours. The pigment comprised 4 parts barytes, one part carbon black and a maximum of 10% of chinaclay or asbestine.

After assembly, the livery areas are treated with knife stopping (B. R. 30/3), This dries in 6—8 hours and consists of 9 parts slate powder, and 1 part zinc oxide suitably tinted with vegetable black in a medium consisting of fossil resins or their esters in treated vegetable drying oils. The stopped areas are faced down with composition rubbing blocks and one coat of red oxide-aluminium primer (BR 30/1) is given. This is followed by one coat of black air drying enamel (BR 30/8) consisting of 2—4 per cent carbon black in a medium consisting of fossil resins or their esters in treated vegetable drying oils having 40 per cent (max.) of volatiles and hard drying in 3—4 hours.

Where synthetic resin process is chosen, one coat of loco black sealer (BR 30/35) is given. This dries in 4—6 hours, has a maximum of 30 per cent volatiles and 50—55 per cent pigment consisting of carbon black, whiting and barytes. The medium is an oil modified alkyd resin with 26 ± 3 per cent phthalic anhydride. The sealer is followed by synthetic black enamel (BR 30/36) having a maximum of 50 per cent volatiles, a drying time of 4—6 hours and a pigment content of 3 per cent to 5 per cent carbon black in the alkyd medium used for the sealer. After applying the final coat, lines are applied followed by exterior varnish.

For outside the cab roof, inside of cab (including boiler backplate, tender front and Bunker front) one coat of general purpose black paint (BR 30/5) is applied. For smoke box, chimney and steam pipe casings—one coat of heat resisting black enamel to BR 30/39 is used. This has the same specification as BR 30/36 with the additional stipulation that a coated panel when heated to 200°C for 3 hours and allowed to cool, should not show any signs of cracking, blistering, change of colour and/or loss of gloss of the paint film.

For buffer beams and casings (engine and tender)—one coat of air-drying enamel (BR 30/9) is applied. This consists of a maximum of 40 per cent pigment in a medium consisting of fossil resins or their esters in treated vegetable drying oils with a maximum volatile content of 30 per cent and a drying time of 6 to 8 hours. The pigment consists of red lakes, toners, pigment dyestuff blanc fixe, and maximum of 10 per cent chinaclay. Finally, a coat of exterior finishing varnish is given. For clothing of outside cylinders and wind deflector plates—One coat of black air drying enamel (BR 30/8) or loco black enamel (Syn.) to BR 30/36 is applied followed by one coat of the appropriate exterior finishing varnish.

PAINTING OF DIESEL AND ELECTRIC LOCOS

The painting of the diesel and electric locomotives more closely approximate to those of the passenger carriages than the steam locomotive. It is however not possible to employ the same methods of pretreatment like phosphating since the heavier gauge steel used for the superstructure is not readily obtainable in the smooth scale free condition similar to that of carriages.

The modern trend is for higher and higher tractive efforts and lighter axle loads and, in order to save on structure weight, unit construction is used whereby the body and under frame are welded together to form a single, stressbearing tubular girder. Owing to the use of thin gauge steel for reducing weight, maximum attention has to be given to effective corrosion prevention. This is specially so when the bodyframe work and the inside surface of the panelling are not readily accessible for inspection and maintenance during the life time of the vehicle.

In the code of practice covering the main line Diesel Loco rust and millscale are removed by wire brushing and cleaned with white spirit. One coat of red oxide aluminium primer to BR 30/1 is given to underframe (interior and exterior), welded areas after removal of welding slag by wire brushing, axles, structure members, side, ends, partition, roof panels, frames and roof members. The bogie is given one coat of primer to BR 30/2 and axles are given another coat of primer to BR 30/2. One coat of general purpose black to BR 30/5 is given to underframe (interior and exterior), brake frame and details. The bogies, axles and wheels are given one coat of black lacquer to BR 30/40 which dries in 6—8 hours. It is based on natural asphalt, resin and vegetable oils with carbon black where necessary and volatiles 50 per cent max.

The interior (walls and ceiling) is given one coat synthetic grey undercoating enamel to BR 30/42 which becomes hard dry in 6—8 hours. It has 55—60 per cent by weight of pigment with a max. of 25 per cent by weight of volatiles. The pigment is composed of barytes, nutile titanium dioxide (45 per cent TiO_2 min.), chinaclay and/or asbestine (15 per cent max.). The medium is an oil modified alkyd resin with 23±3 per cent phthalic anhydride. The finishing coat is synthetic grey enamel to BR 30/43 which is similar to BR 30/42 excepting that the pigment is 30—35 per cent and the volatiles below 40 per cent by weight.

On the upper surface of the interior of cab (walls and ceiling, doors, partition etc.), one coat of synthetic cream undercoating to BR 30/46 is given followed by one coat of vellum enamel (synthetic) to BR 30/47 which are similar to grey enamels. The lower surface is given one coat of green undercoating followed by one coat of green enamel (synthetic). These hard dry in 4—6 hours, the medium being oil modified alkyd resin varnish with 26±3 per cent phthalic anhydride. The undercoat contains 50—55 per cent pigment consisting of lead chrome green, asbestine, barytes (barium sulphate 60 per cent max.) and suspending agent (15 per cent max.). The finishing enamel contains 20—25 per cent of a pigment similar to the above, the barium sulphate content being 30 per cent maximum and suspending agent 10 per cent maximum on pigment.

Japanese Railways : The exterior of engines, cab and tender is sand blasted and given a coat of oil primer followed by oil primer surfacer. Two coats of oil putty are applied by spatula and ground by stone and water. Two coats of filler are then applied and sand papered using water. Two coats of synthetic coach-finish (alkydbase) are then given, followed by sand papering with water. A third coat of synthetic coach finish is applied followed by lettering. The frame of loco engines and Diesel cars are given an anticorrosive primer followed by 2 coats of black enamel (alkyd base) while under gear is coated with black oil paint. The oil primer has 23 per cent gold size, 22 per cent synthetic resin varnish 10 per cent zinc oxide, 15 per cent red oxide 10 per cent red lead and 20 per cent whiting. The oil primer surfacer and filler have 35 per cent mixing varnish, 5 per cent white spirit, 10 per cent white lead, 9 per cent barytes, 20 per cent zinc oxide and 20 per cent whiting.

Indian Railways : With a total route mileage of 35,080 on the 31st March, 1959, Indian Railways form the largest rail transport undertaking in Asia, and the fourth largest railway system in the world. Owned and operated by Government it is the second largest among the nationalized railways in the world, the first being those of the U.S.S,R. On the 31st March, 1959, the Indian Railways had 10,278 locomotives comprising 6349 BG, 3527 MG and 402 NG. Except for 181 diesel locomotives and 91 electric locomotives, all the rest are steam locomotives.

The evolution of the WG steam locomotives : Twenty years ago, there were about 500 different types of locomotives in use. The rationalization of locomotive power with a view to eliminate all non-essential classes of locomotives began in 1910, with the introduction of the B.E.S.A. (British Engineering Standards Association) locomotives. The gradual growth in loads on the one hand and the deterioration in the quality of coal offered to railways on the other, made it necessary to have more powerful units with a larger grate area for the efficient combustion of coals yielding 15 to 22 per cent ash. Between the years 1923 and 1926, a new series of locomotives were designed in the U.K. for burning Indian coals. These were the 'X' class for the BG, 'Y' class for MG and 'Z' class for NG. During the war, years 1943—46, the import difficulties from the U.K. necessitated the purchase of about 1,100 American War Model bar frame locomotives, based mostly on 'X' class standards.

With increasing pressure on railways to abandon the use of better quality coal for metallurgical purposes, it became necessary to use low grade non-coking coal which has generally about 7 per cent lower available calorific value than that of coking coals. The post-war Indian Standard WG locomotive being built in Chittaranjan is a result of exhaustive research and the experience gained with the previous types of standard locomotives of both U.K. and U.S. origin. It is a 2—8—2 type BG goods engine, weighing approximately 123.5 tons empty and 174 tons in full working order as compared to 127 tons in full working order of an HGS loco, one of the earliest BESA standards. It has a boiler working pressure of 210 lbs. sq. in. with two 21.⅞" x 28" cylinders and 5'-1½" dia. coupled wheels. The boiler is capable of a superheat temperature of 700°C with a grate area of 46 sq. ft. It can haul trains of 2,000 tons over level sections at a speed of 45 miles per hour. As fuel costs in India now reach 50 per cent of the total costs for the supply and maintenance of locomotive power, the new locomotives had to be specially proportioned to burn Indian non-coking coals efficiently. The axle-loads have been restricted to 18½ tons for the Broad Gauge units and 10½ tons for the Metre Gauge units, so that schemes for increasing the strength of track and bridges may be deferred with a view to conserve the limited steel resources.

The necessity for electric and diesel locomotives : With the growth of Calcutta and the Coal Field area in Bengal and Bihar resulting in a phenomenal increase in traffic, with the proposed setting up of Steel Plants and other industries, the need for replacing steam locomotive became urgent. The capacity of the steam locomotive to haul loads is limited by the size of the boiler, and its availability due to watering and coaling and by the need to clean out, repair and wash the boiler frequently. This is not the case with Diesel or electric traction. By increasing the speed or frequency of service an increase in the line capacity can be obtained without the costly construction of new lines. Since a large scale changeover from steam to diesel is not possible due to dependance on foreign sources for fuel supplies, it was decided to electrify the entire suburban area within a radius of 60 to 70 miles of Calcutta and to extend the electrification on the main line up to Gomoh during the Second Five Year Plan.

Though an electric locomotive costs much more than a steam locomotive this higher cost will be more than off set by the much greater availability of the electric locomotive where a minimum traffic density exists since a far less number of electric locomotives will do the same work as a larger number of steam locomotives. If to this is added the further saving brought about by the utilisation in thermal stations of low grade coal, for which there is likely to be no other demand, it will be readily understood that the cost of fuel will be considerably less under electric traction.

A lot of working time in a steam locomotive is spent in coaling and watering. It takes time to get up steam while an electric locomotive can pick up speed almost immediately. The availability of an electric locomotive may be as high as 2½ times that of a steam locomotive. An electric locomotive not doing any useful work on line does not draw any electric current, while an idling steam locomotive on line cannot but use coal and lubricants. An electric loco can draw an unlimited supply of energy from the overhead electric conductor while negotiating a rise, whereas a steam or diesel loco must depend on its limited capacity.

Since electric traction requires an expensive fixed installation consisting of sub station and over head equipments to supply current, it has been decided to operate initially 1293 miles of Indian Railways by diesel electric locomotive proper as an interim measure to take care of the increased traffic till such time as the tracks can be electrified. Out of this, 1020 will be on the broad gauge and 273 miles on the metre gauge sections. A feature of the diesel locomotive is that it generates electricity by itself which, in turn, works the locomotive through six traction motors. Dieselisation of part of the metre gauge Saurashtra region of the Western Railway became necessary due to the poor quality of boiler feed water. The favourable pay load/total train load ratio of the Diesel Rail-Cars necessitated their adoption for branch line services for shunting in the yards for hill or other sections with high gradients and for suburban traffic around industrial towns where electrification cannot be justified.

Standardization of loco painting schedules in Indian Railways : A large organization like the railways has always to look to the economic side. In view of the fact that the Indian Railways purchase annually more than Rs. 2 crores worth of painters materials, it is essential that the selection and formulation is based on local availability in large quantities at low cost. The phenolics and alkyds which are the backbone of the modern paint industry require large quantities of phenols and phthalic anhydride in which India is deficient. On the otherhand, Indian Forests can provide renewable sources of invaluable raw materials for industry. For instance, India holds monopoly in plant products like cashew nut shell liquid and bhilawan shell liquid which provide perennial sources of cheap phenols. Attempts have, therefore, been made to utilize these products in making air drying and fire resisting surface coatings for the protection of locomotive etc.

At present, the Eastern Railway is using black paint for boiler lagging plates, awning (cab), wheels, frames, pipes, cow catcher, buffer, buffer-beam, firebox, tenders, side tanks, platform plate, cylinder lagging plates (outside) and ash pan. Red oxide paint is given for bogie frame, tender frame and inside of cylinder lagging plates. Black japan followed by varnish is given for smoke box.

In the Southern Railway, red oxide paint is used for the outside of boiler barrel and firebox, interior of engine, underframe and dragbox. Bituminous black or black enamel is applied for outside of clothing plates, ash pans, smokebox and chimney, wheels, axles, tender underframes (interior and exterior), exterior of engine underfame, water tanks (exterior), coal bunker, cab roof (outside), engine and tender bogies. The inside of clothing plates of boiler, cylinder etc. are given either red oxide paint or bituminous black.

In the Ajmer shops of the Western Railway, oil paint (buff colour) is used for cab, chocolate paint for boiler, bufferbeam plate (first coat) tender (inside) and inside of lagging, black paint for outside of lagging and underframe and signal red for the finishing coat of bufferbeam plate. In the Dohad shops, iron oxide paint is used for inside of tanks, engine frame and lagging. Bituminous black paint is used for ash pans, tender coal bunker and top of cab roof, black paint for outside of tender cab and engine lagging, black japan for outside of smoke-box, black enamel for smokebox and lagging plates, varnish mixed with paint black for last coat on engine and tender (outside) and green enamel for cab roof inside.

In the Parel Shops of the Central Railway, red oxide oilpaint is applied to boilers and the inside of lagging plates of engines, while black paint is applied on tenders and the exterior of lagging plates of engine. In the Kurdwadi shops, Mid-green enamel is used for tender and cab and heat resisting black enamel on boiler lagging plates followed by a final coat of enamel and varnish (50 : 50).

In the case of WG locomotives at Chittaranjan, red lead paint is used for the outside of boiler and firebox. Zinc chromate/red oxide primer to IS 107 is used for inside of clothing plates, tender, coal bunk and under gear. While a finishing coat of black japan to IS 341 is used for coal bunk, and undergear, black japan to IS 1257 is used for smokebox and engine and synthetic black enamel to IS 520 for the tender.

It will be seen from the above that schedules and the materials used vary not only from railway to railway but also from shop to shop in the same railway. The existing painting schedule for steam locomotives given in R/32 1954 is neither satisfactory nor complete. For instance, Clause 86 of this specification requires that the

ELECTRONICS IN SIGNALLING

The first electronically-operated system of signal interlocking in the world has been installed at Henley-on-Thames in a British Railways' Western Region signal box.

The equipment is designed to perform the basic function of all railway signalling apparatus by controlling the interlocking of signals so that adequate distances are maintained between following trains or those that could cross or approach each other. It will do this by means of computer-like techniques, using suitable arrangements of plug-in electronic " logic " units in which transistors and magnetic cores perform " logical " switching operations.

Designed to satisfy British Railways' stringent safety requirements, the system has many advantages. It should substantially reduce long-term maintenance costs and make economies possible in the storage of replacement parts. Signalling installations themselves could be reduced in size, as well as the buildings required to house them. In the present instance at Henley-on-Thames the electronic equipment occupies only one third of the space taken up by the previous manually-operated mechanical interlocking equipment.

To permit the movement of a train, the signalman simply turns a switch representing the point of entry to the required route, and pushes a button representing the exit of the route.

Should the " logic " units of the electronic interlocking system " decide " that the safety requirements for the movement have been proved, then the route can be cleared. All the necessary points can be set and locked in the required direction, and the correct signals will then clear. Any conflicting signals remain at " red ", and in the event of any electronic component breaking down the system will immediately become " fail-safe ", switching all the appropriate signals to " red ".

If the new method now under trial proves as successful as is expected, once the doors of the equipment racks are closed the electronic components should carry on for years without attention.

The scheme is being developed in collaboration with Mullard Equipment Limited.

(Continued from page C.L.W.46)

outside of boilers and firebox should be painted with two thick coats of pure red lead before being clothed. The first coat must be put after the pressure is released and the boiler proved tight and while the plates are hot. It must have sufficient lead colour to make it easily distinguishable from the second coat which is applied when the boiler is cold.

The clothing plates, frames, splashers, platforms, and wheels and all other parts of the engines and tenders not finished bright, after having been thoroughly filled up and rubbed down to a good surface, are to be painted with two coats of lead colour, the first coat to have sufficient red mixed with it to make it easily distinguishable from the second. Clothing plates are to be painted on the inside with two coats of red oxide. Water tanks are to be painted on the inside with one coat of boiled linseed oil and when dry with two coats of red oxide. The chimney is to be painted with two coats of best black japan, one just before the engine is steamed and the other after steaming.

In view of recent developments in other countries the question of using heat resisting and other similar materials like synthetic paints for locomotives is under review. To decide upon the best types of paint to be used consistent with economy, trials have been carried out on WG locomotives at Chittaranjan with inexpensive CNSL based compositions developed by the Chittaranjan Sub-Centre as also alkyd based paints. Though CNSL paints are acid, alkali and heat resistant, they are found to lose gloss within a short period. This does not, however, affect the protective value since this is due to superficial chalking and the original gloss can be restored, if at all necessary, by polishing. On the experience gained with the above trials, further trials with modified compositions have been planned to enable the development of a uniform painting schedule for steam locomotives.

Instead of red lead which is not only toxic but is also expensive, being made from imported lead, ' red mud ', an inexpensive byproduct of the Indian Aluminium industry has been used as the anticorrosive pigment. Compositions based on Bhilawan Shell Liquid, another naturally occurring phenol, in which India holds a monopoly have also been used.

Modern Trend of Train Lighting

By *S. H. Raj*, M.E. (Tokyo), M.I.E.E. (Japan)

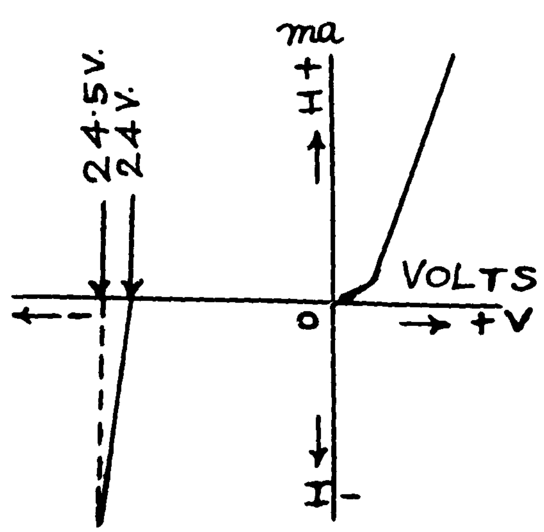
THE present practice of lighting the coaches in the trains in our country is by incandescent lamps and their supply is from a 24 volts D. C. system. This supply is made available by a generator operating in parallel with a battery placed under the bogies. Illumination from incandescent lights are now getting rather obsolete because of their efficiency as well as their distribution of illumination being very low compared with the fluorescent or other mercury vapour lamps.

In all the advanced countries like the United States and Japan the train lighting is done by fluorescent lamps. But these lamps require a minimum voltage of 80 to 100 and preferably of an a.c. supply to avoid the darkening of the tube on one side. So, the generator supplying power for lighting and other appliances in the coaches are mostly alternators in these countries which are of the self-excited type. In addition generation by alternators eliminates the difficulties of commutation and radio frequency interference which are inevitable in d. c. generators. Now that India has started different factories to manufacture coaches for trains in her railways, it is high time that this method of power generation for lighting is adhered to in these coaches.

When the trains are operated by an electric traction system, the incoming supply is always available which drives the motors for the alternators for lighting and other purposes and so there is no necessity of any high power standby supply by batteries. The generation here is of 100 volts or above and the motors and the generators are compensated for the load fluctuations to run at a constant speed and a constant voltage respectively, by suitable feedback controls. But in the case of diesel locomotive or steam locomotive driven trains the generators are driven from suitable belt drives from the wheels of the bogies. So, only when the generator reaches a definite speed, it will be in a position to supply the power at the required voltage and so a standby supply is absolutely necessary in this case. These standby supplies are the 24 volt batteries and the generator is also rated at 24 volts. A section of this generation is directly rectified and connected in parallel with the batteries and the remaining portion is stepped up to the required voltage of 100 or above and fed to the fluorescent lighting. Below a certain speed when the generator is cut out the lighting supply is taken from the batteries and fed to the incandescent lamps that are placed at some regular intervals in between the fluorescent lamps. In advanced countries the stopping time at the platforms of stations are so limited that the capacity of the standby supply need not be very heavy whereas in India this time is so high but the author hopes that this will be gradually reduced in due course.

In the case of the former kind of generation, the alternator has to be compensated only for load variations by its feed back controls whereas in the latter case it has to be compensated both for the speed and load variations. Or in other words, in the latter case the feed back control should be frequency and load compensated. To keep the reference constant in such a control as well as to keep the gain of the detector circuit reasonably high, is really a problem with the designers of this feedback control. The author has written two papers already on this subject which were published in the November 1960 and August 1961 journal of the Institution of Engineers.

In this present paper a more efficient, compact as well as an economic method of feedback control that can be adopted for these alternators is given. In this connection, it should be remembered that as these alternators are increasing in size day by day due to the increase of loads in the coaches, magnetic amplifiers are employed for the control of the field of the alternators for compensating the fluctuations in load and speed.



(FIG. 1.)

With the advent of semi-conducting materials various changes have happened in the control systems of electrical equipments. It is also believed that in due course that the magnetic amplifiers will be replaced by controlled silicon rectifiers but at present the cost of these rectifiers are prohibitive and so the magnetic amplifiers will be retained for some more time to come. But in the detector stage here, a diode which is called a ZENER DIODE is used and its characteristics are given in the Fig. 1. On the positive side this diode behaves just like those of the other semi-conducting diodes whereas on the negative side it takes a very steep slope in the reverse current and the voltage at which the reverse conduction starts can be adjusted in the design of the diode itself. In the case of the 24 volt generation a zener diode which will fire at 24 volts on the negative side will be chosen, if the field coils of the generator are going to be operated at 24 volts. Because of the steep slope at the firing point, *the gain of the detector stage is very high and so a low gain magnetic* amplifier can also be employed in this case keeping the overall gain constant. Within a voltage variation of 0.5 volts the current conducted on the negative side reaches a very high value and so on no case the voltage across the zener diode should be allowed to exceed 24.5 volts. This is achieved by placing a neon or other discharge tubes which will fire at exactly 24.5 volts in parallel with the zener diode. There might be a tendency of the characteristic shifting due to temperature variation and this shift is compensated for, by placing a Thermistor across the Zener diode.

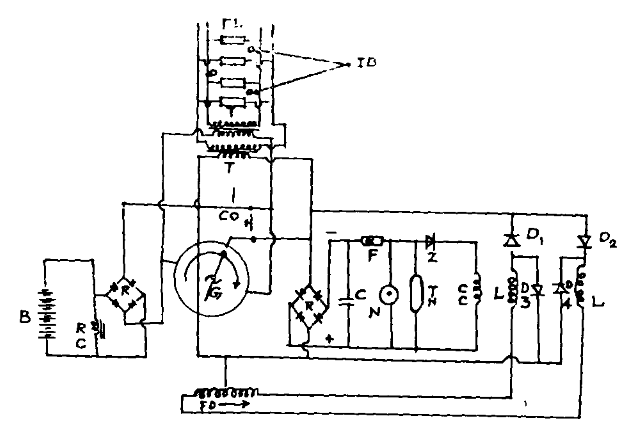


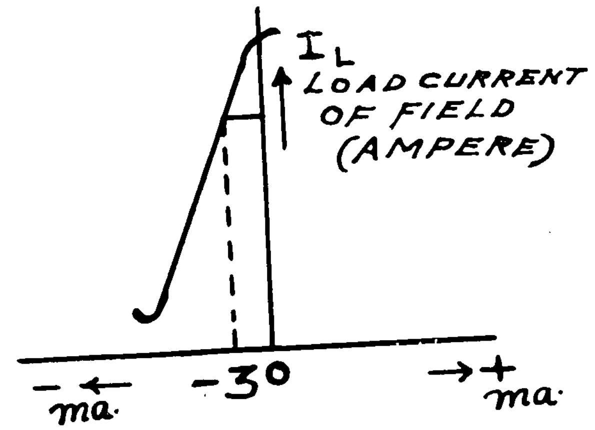
FIG 2

PARAMETERS

G	:	Two phase generator
R	:	Full wave rectifer bridges
C	:	Filter condenser
F	:	Replaceable fuse cartridge
N	:	Neon or any limiting tube
TH	:	Thermistor
Z	:	Zener diode
CC	:	Control coil of magnetic amplifier
L	:	Load coil of magnetic amplifier
D1D2	:	Direct load rectifier for magnetic amplifier
D3D4	:	Damper load rectifiers for magnetic amplifier
FD	:	Field coil of generator
RC	:	Relay coil of the cut out
CO	:	Cut Out
B	:	Battery
TT	:	Transformers for the two phases
FL	:	Fluorescent tubes
IB	:	Incandescent bulbs

The above circuit gives the procedure for employing the Zener diode in the control circuit of the magnetic amplifier which is itself in a doubler circuit. *Protection is assured by the limiting tube and the fuse cartridge, which* can be replaced in case of any surge. The filter condenser takes care of any momentary surges. One phase of the generator feeds the field circuit and the other phase feeds the battery as shown in the figure. In addition both the phases feed the fluoroscent lamps through the transformers alternatively to avoid the flickering effect. Incandescent bulbs are placed at regular intervals and they are fed from the battery source when the generator is cut off line. The relay coil in the battery circuit cuts off the generator when its voltage goes below the prefixed level, through the cut out which are interlinked. At the start, the generator is fed either from the battery or self excited by providing suitable connections.

The performance of the magnetic amplifier is given in the Fig. 3. Due to the high gain in the detector circuit and also the gain in the magnetic amplifier, the whole circuit should be damped in a proper way and this is achieved by the damper diodes in the doubler circuit of the magnetic amplifier. In Fig. 3 the ampere represents the control current and the ordinate represents the load current handled by the magnetic amplifier through the field coils. The reference point is taken here as minus three milli-amperes and the operating zone is rather very limited. If the generator voltage is 24 volts the inverse conduction point of the zener diode should be so chosen such that the voltage drop in the control coil by the reference current is taken into account. If the control current is three milli-amperes as in this case and the control coil resistance is 500 ohms. then the voltage drop in the control coil is 1.5 and so the zener



(FIG. 3.)

diode should be chosen from the 22.5 volt class. Then the protective tubes as well as the thermistor should be correspondingly rated.

When this circuit was actually put into operation the fluctuations were practically zero and the off-set under any varying conditions of speed and load was found less than 0.2 per cent, when recorded in a pen-oscillograph. When the starting is by self excitation the starting time was found less than 2 sec. when the critical speed was reached. Momentary surge during starting conditions occur but these are very quickly damped by the damper circuit and the off-shoot of voltage which exists on the first cycle does not harm the detector circuit as it gets absorbed by the filter condenser. This surge can also be completely eliminated if the battery takes the initial excitation.

This method of self excitation becomes very compact and also very reliable and these are getting introduced very fastly in the advancing countries. But for the magnetic amplifier all the other components are very small and the entire feed back unit is made as a compact feed back control box and mounted on the generator itself. The author has further conducted research to reduce the size of the magnetic amplifiers used in these cases and thereby the overall cost of the feedback control equipment and these are being patented and will be published in due course by him. This research was conducted in Japan and the author feels very grateful for all the assistance given by the coach manufacturers as well as the universities there.