Indian Railways Workshop Magazine

ol-8 NO-1

vember-January 1962.

The Indian Railways Workshop Magazine

907/1.62 Verified 338

ANNUAL NUMBER

Vol. VIII No. 1 NOVEMBER – JANUARY 62 Price 50 nP.

CONTENTS

Announcement

We have great pleasure to inform all our Railroad Engineers and advertisers that we have decided to publish a special supplement entitled **The Indian Railways Locomotive Carriage & Wagon Shops Supplement** along with our February-April 1962 quarterly edition. This will contain interesting articles of very high technical nature contributed by eminent railroad engineers on all aspects of locomotive design, carriage and wagon construction, advantages over Diesel traction and economics of electric traction etc.

If you are interested in advertising in this Supplement, you are requested to contact the undersigned on or before 30th April 1962. Technical write-ups and articles from rollingstock builders would be published free of charge.

For other details please contact:

POST BOX NO. 21
MANOJIAPPA STREET
TANJORE (South India)

Technical Editor

Steam, Diesel & Electric Traction Supplement

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 panels, 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 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 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.

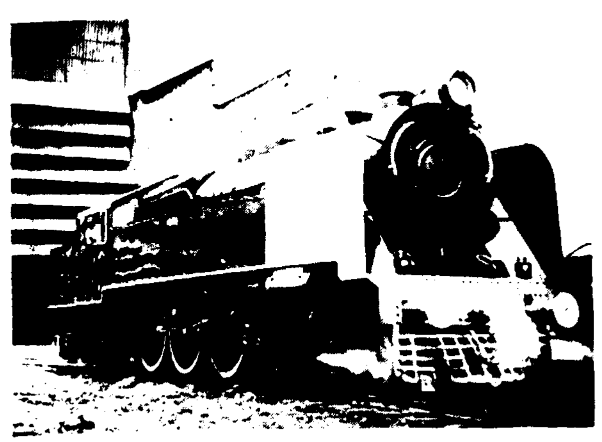
For many years Voke's filtration equipment has been accepted and used in railway system expansion programmes as the first line of defence against atmospheric pollution and contamination of all kinds. It has played a very valuable and important part in protecting railway equipment both in Great Britain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

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.

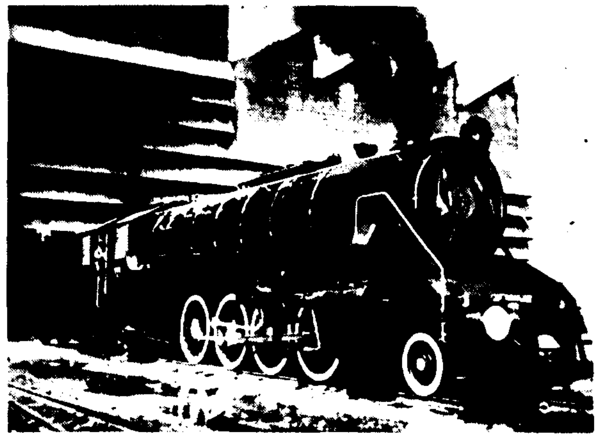
D.C. 3600 H.P. Straight Electric Locomotive now manufactured in Chittaranjan Locomotive Works.

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.

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-

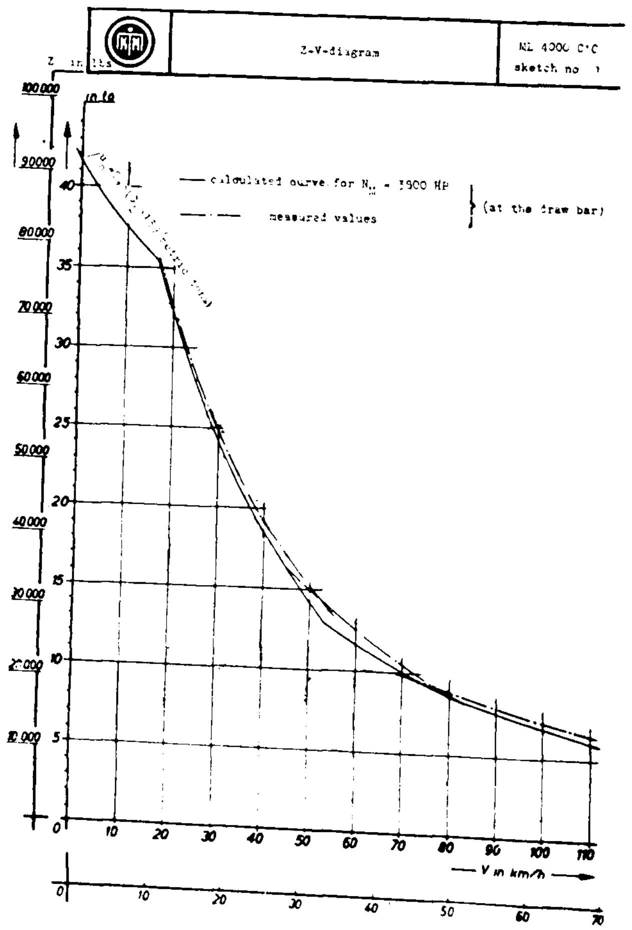


Fig. 1 Tractive effort/speed diagram comparing the theoretical with the measured effort at draw hook

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.

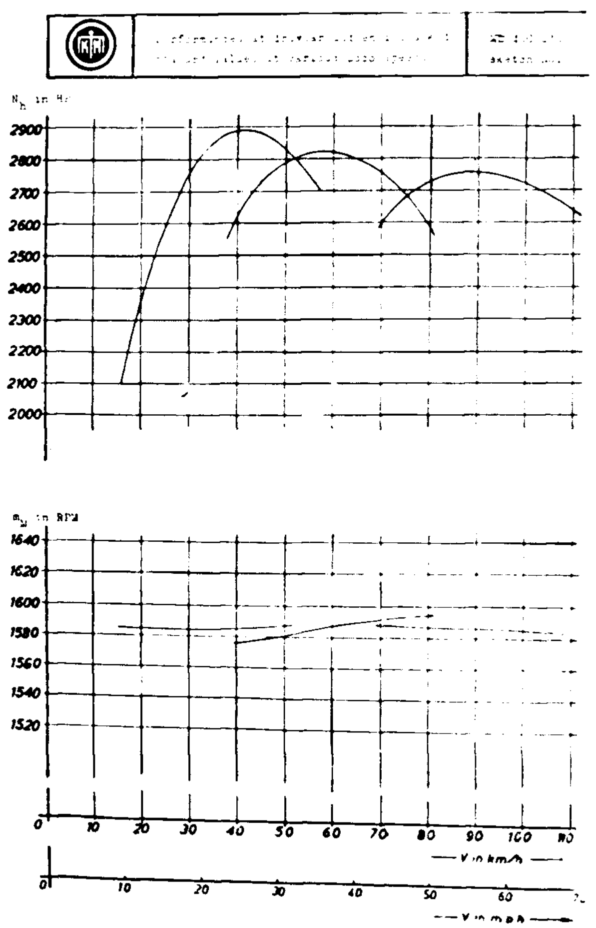


Fig. 2 Measured values of effort at draw hook and engine speed in relation to locomotive speed

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

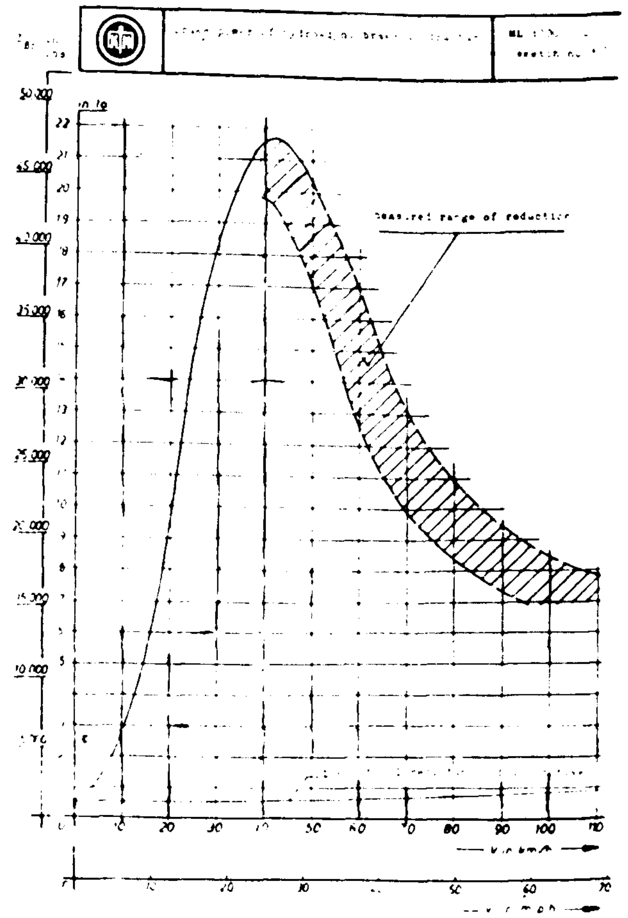


Fig. 3 Hydro-dynamic brake
Brake effort measured at draw hook

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

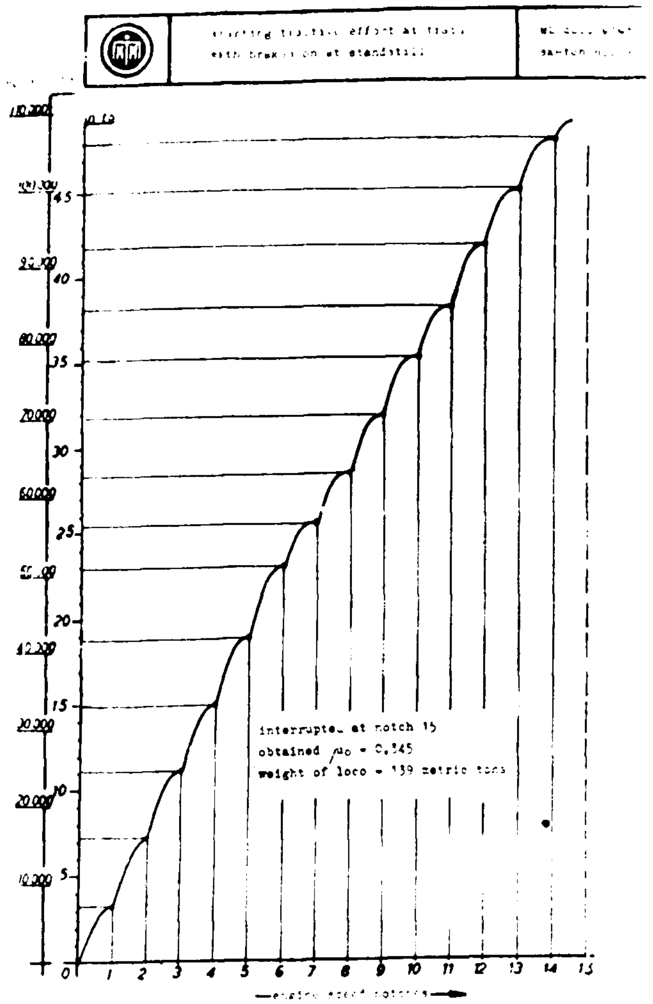


Fig. 4 Tractive effort at start measured with braked train

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 Experiemental 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		
or 5,560	82	2×1700	2×1600
or 6,890	64		
or 9,190	32		
5,560	100		
or 6,890	86		
or 9,190	54	2×1600	2×1500
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'

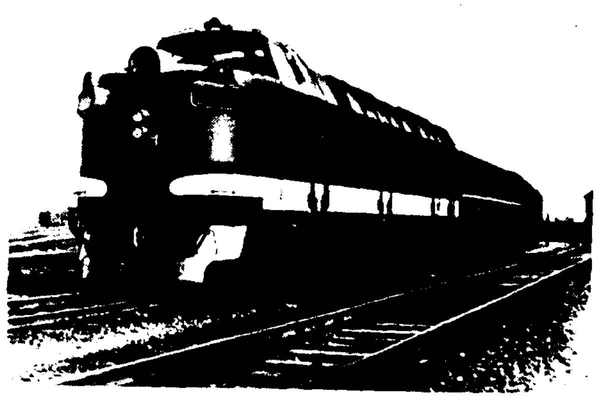
Gradient/speed diagram (1 locomotive with goods train 875 metr. t) DM 6840

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

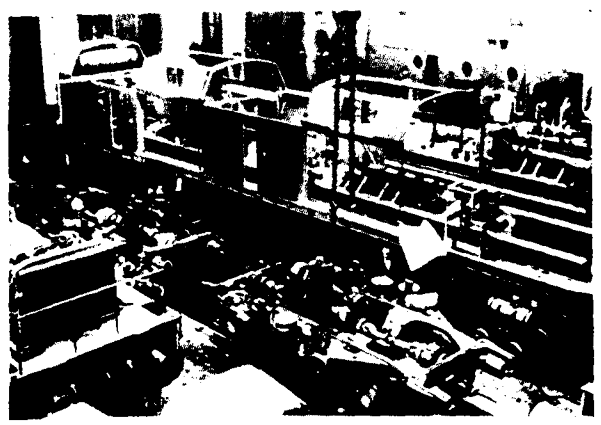
Description of the Diesel-Hydraulic Locomotive ML 4000 C'C'

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 preheated, 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.

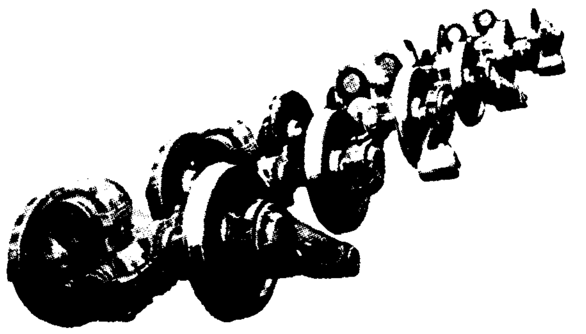
7. To improve the cooling effect in narrow mountain tunnels which have become heated by exhaust gases, each cooler is equipped with a *water spray device* embodying a row of downward spraying nozzles fixed outside the upper end of the cooler. Through these nozzles, one in front of each cooling block 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 intercoolers 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.

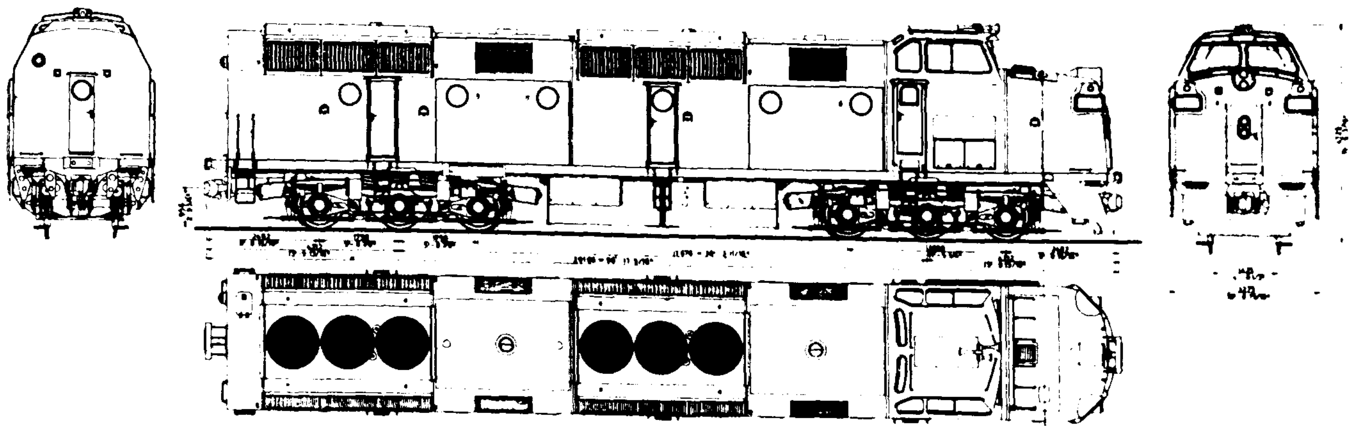
The *hand brake* only acts on the two brake shoes of one wheel of the central axle of the front bogie. It is a spindle brake with chain transmission operated by a handwheel fixed to the rear cab wall.

To reduce the wear of brake shoes on long down-hill lines the locomotive is equipped with two *hydro-dynamic* 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.

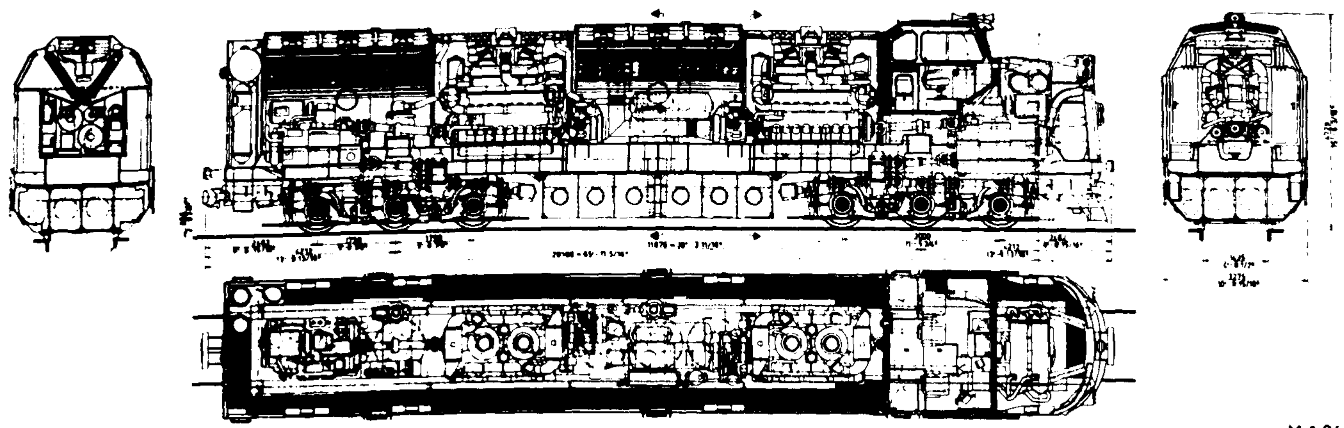
The master controller serves for initiating both the drive and the brake operations : for driving when its crank is moved from its zero position towards the engineer, and for braking when moved in the opposite direction.

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



KRAUSS-MAFFEI AKTIENGESELLSCHAFT MUNCHEN-ALLACH



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

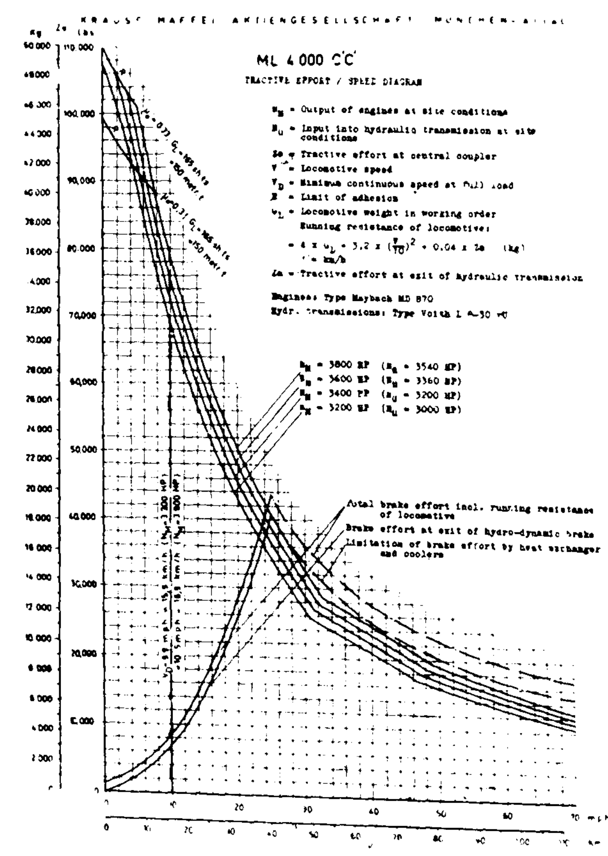
A lead battery is placed on both sides of the locomotive in each of the two outer recesses of the fuel tanks. At an operating voltage of 64 V it has a capacity of 385 Ah referred to 5 hours discharge). While the locomotive is working, the battery is continuously charged from the starter-dynamoes mentioned 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

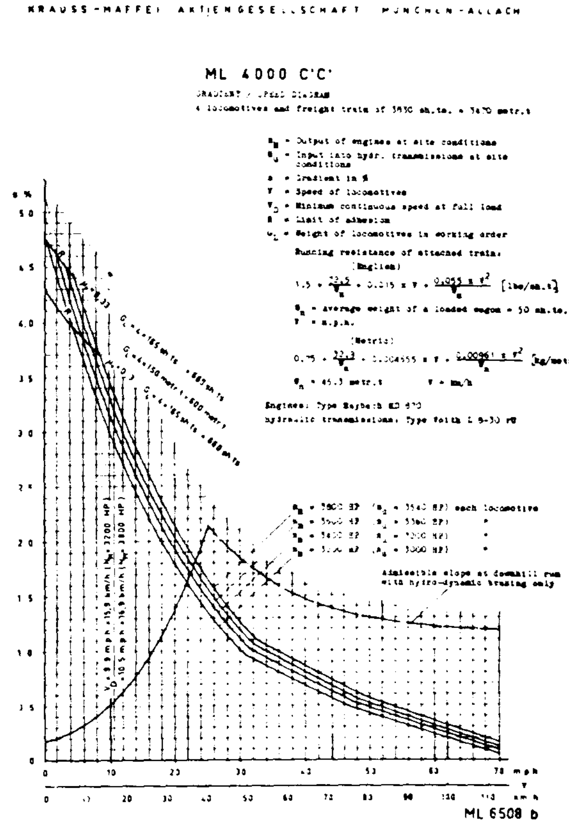


ML 6 505 b

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.



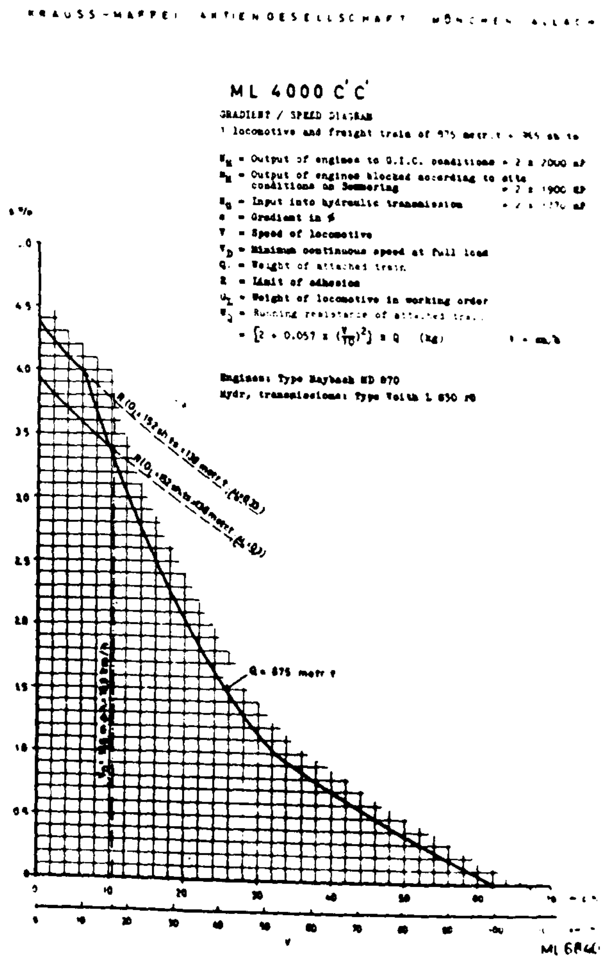
THREE-AXLE BOGIE OF KRAUSS-MAFFEI DIESEL LOCOMOTIVE

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).

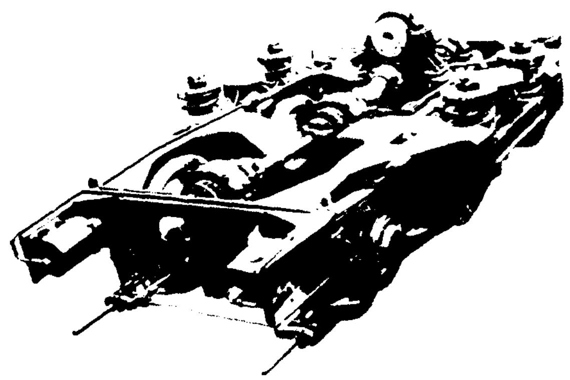
An intermediate gearbox (17) firmly connected to the bogie frame allows the use of short

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.

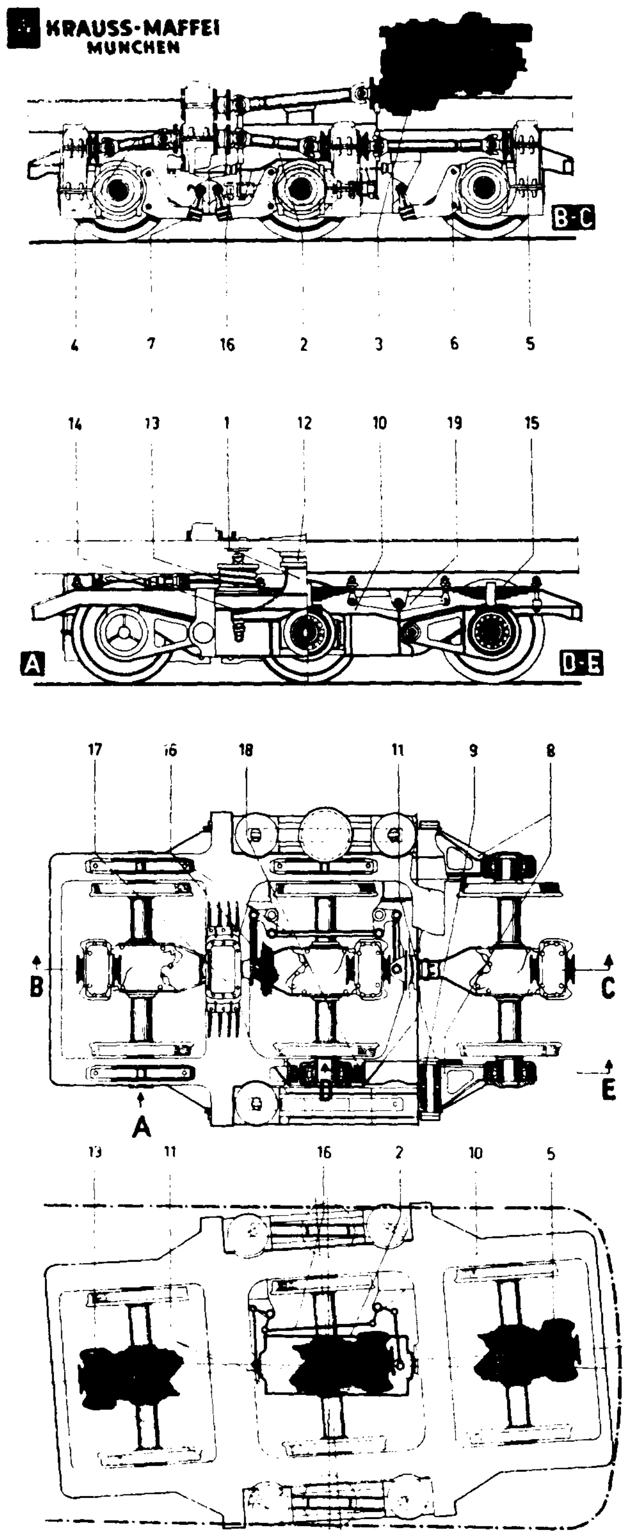
2. The rigidity of the box-type welded axle guiding links (8) which are hinged by means of rubber blocks (9) warrants *invariably* good running characteristics of the locomotive on the track as well as an elastic absorption of lateral shocks occurring on the wheel flanges. In a similar way, the rubber 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

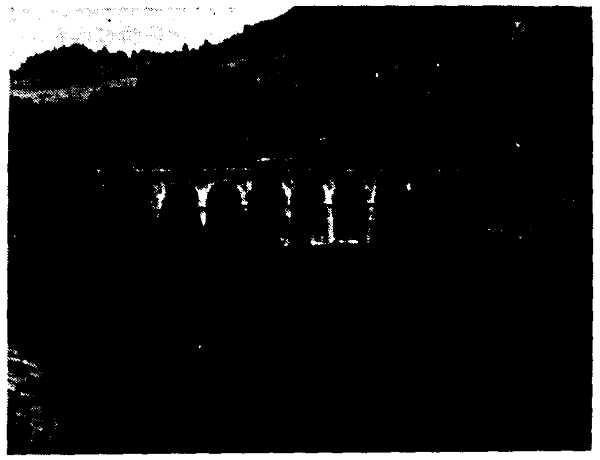
Since the locomotive ML 4000—as to the American custom—is equipped with one driver's cab only the

(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)	northern gradient (t)
52	1'E	82.7	1620	396	331
42	1'E	94.0	1800	495	441
95	1'E1	79.2	1037	364	331

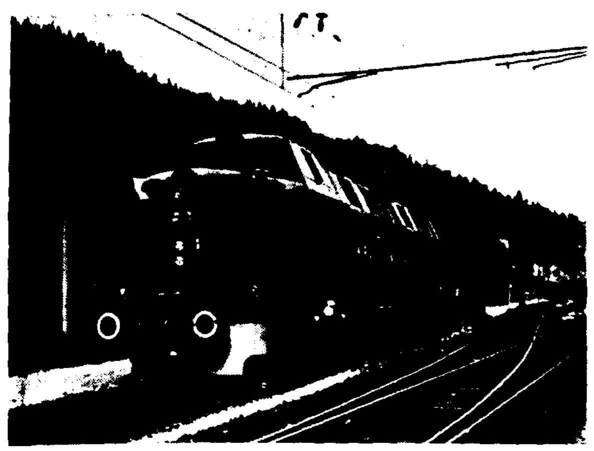
(b) Straight electric locomotives

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)	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 tractive effort calculated at the corresponding speeds for the different inclinations. With this calculation the tractive efforts at the drawbars 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 factor was introduced in the comparing calculation.

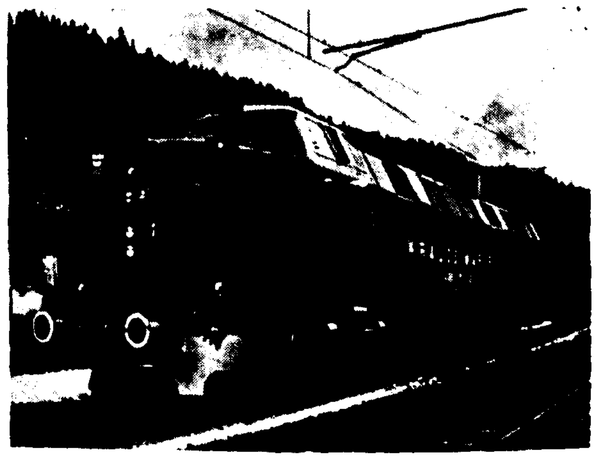
Comparison of the measured tractive efforts with the computed tractive efforts of the three parts of inclination on the northern gradient and the two parts of inclination on the southern gradient.

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.

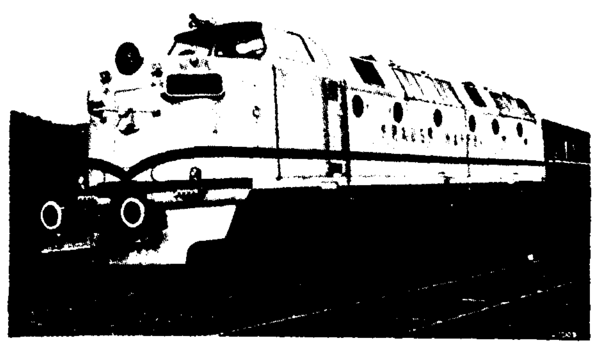
The performance values obtained by this locomotive on the Semmering line exceed all performance values of Diesel locomotives hitherto known and herewith confirmed that this type of Diesel locomotive can be regarded as the most powerful Diesel locomotive of the world built up today. A great number of 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.

Condensed Description of the Voith Turbo Transmission type L 830 rU

GENERAL

THE Voith Turbo Transmission type L 830 rU is a three-stage hydraulic power transmission incorporating three hydraulic torque converters (based on the 'Fottinger' principle) and a built-in reversing gear. This Turbo Transmission has been designed to be interposed as power transmission between the diesel engine and the axle drives of the locomotive. One out-put flange is provided which is arranged on the same side as the input flange. From this output flange, through a cardan shaft, a distributor gear and, by means of additional cardan shafts, the axle drives of the locomotive can be driven. There are two additional power take-offs for the connection of such auxiliaries as e. g. oil pump used as fan drive, and dynastarter.

The Voith Turbo Transmission is a fluid drive in which the power is transmitted by a fluid. The mechanical energy delivered by the diesel engine is converted into 'kinetic' energy in the power-absorbing member of the transmission (pump impeller), and this energy is transformed back into 'mechanical' energy in the power-delivering member (turbine runner). The torque converters are made up of three components: a pump impeller, a turbine runner and a stationary reaction member (stator). All pump impellers are driven from the engine through gears. Gears are also interposed between the turbine runners and the output shaft. The stator (guide wheel) is rigidly bolted to the casing of the the Turbo Transmission and takes up the reaction moment. The characteristics of the three hydraulic torque converters are such as to provide over the entire operating range a tractive effort curve of parabolic shape as a function of the track speed.



Diesel-hydraulic locomotive ML 4000CC (Krauss-Maffei AG, Munchen-Allach) equipped with 2 Voith Turbo Transmissions, type L 830 rU, and attached hydrodynamic brake

Each torque converter (stages I, II or III) is assigned a well-defined speed range of the locomotive. The arrangement is such that always that hydraulic circuit is automatically energized which provides optimum efficiency for the prevailing track speed and engine filling conditions. Thus, torque converter W I is used for starting and the low-speed range, torque converter W II for the medium-speed range, and torque converter W III for the high-speed range. Or in other words, torque converter W I, as to its blading, is designed as starting converter, whereas torque converters W II and W III are designed to accommodate running conditions.

The torque converters are brought into action and cut out by filling and emptying of the oil circuits (mineral oil). The changeover is fully automatic under the control of the track speed and the engine output, use being made of an automatic control system. The changeover from one circuit to another is brought about by purely hydraulic means, and so, there are no shocks nor is there any wear and tear. At the changeover point, the power flow is not interrupted as one circuit is emptying while the other is fiilling. There is even overlapping of these operations. All gears are permanently in mesh. This fully hydraulic operation of the Voith Turbo Transmission provides excellent dependability.

With the Voith Turbo Transmission type L 830 rU, the hydraulic part has been physically separated from the mechanical part. This arrangement provides not only individual adaptation to all locomotive designs, but at the same time such parts as are subject to wear and tear: gears, claw clutches, etc., are readily accessible for inspection and maintenance. At the same time, as may be seen from fig. 2, no rotating output gears are accommodated in the oil sump of the hydraulic transmission proper.

Also with respect to the control equipment of the Turbo Transmission, such as governor, solenoid, lamellar filter, changeover valve, etc., all these parts are grouped on one side of the Turbo Transmission so as to be readily accessible when fitted in locomotives with a service aisle.

Turbo Transmission type L 830 rU is a new design into which has gone our experience of many decades in the field of hydraulic power transmissions. These Turbo Transmissions allow to design high-power packs with low axle loads for small space requirements.

GENERAL DESIGN

Fig. 2 is a schematic section through this Turbo Transmission type. The driving shaft (input shaft) drives the hollow primary shaft through gear wheels (1), (2). On the primary shaft, the pump impellers (Pu I), (Pu II) and (Pu III) of the respective torque converters W I, W II and W III are attached. Changing the transmission ratio of gear wheels (1) and (2) allows ready adaptation to different high-speed or low-speed diesel engines. The turbine runners (Tu I), (Tu II) and (Tu III) of the three-torque converters are bolted to the secondary shaft (solid shaft). When torque converter W I or torque converter W II or W III is filled, the torque created in the turbine runner is transmitted to the output shaft through the secondary shaft, when the reversing gear is in the 'forward' position, through gear wheels (5) and (7), and through gear wheels (3/4) and (6/7) when the reversing gear is in the 'reverse' position.

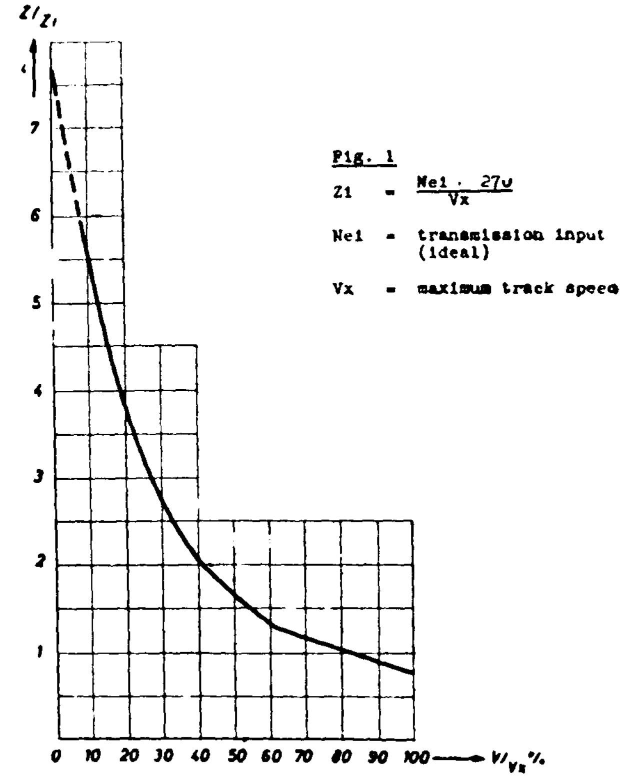
CONTROL

The main control of the Turbo Transmission, by means of which the oil delivered by the filling pump is directed to the hydraulic circuits, is under the control of a simple preliminary control which receives its impulses from the engine output and the track speed. This preliminary control system comprises a small spring-loaded centrifugal governor, which, by means of pressure oil, positions the control pistons of the main control system so as to initiate the filling and emptying of the hydraulic circuits under the control of both the position of the fuel controller and the track speed of the vehicle. In this way, depending upon the position of the fuel controller and the track speed, that hydraulic circuit is energized which provides maximum efficiency.

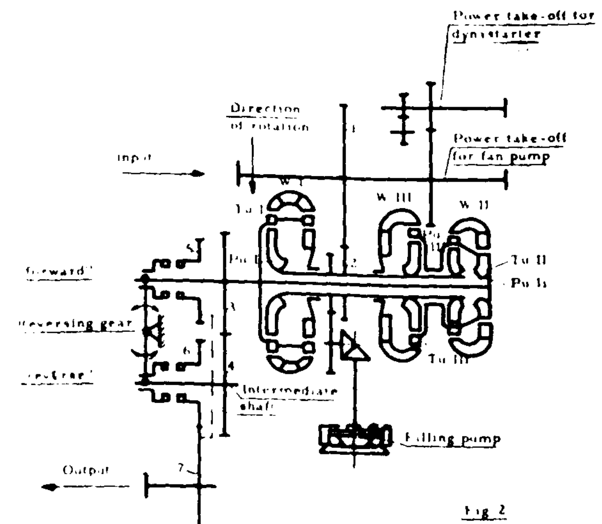
The fuel lever of the engine is linked with the control of the Turbo Transmission in such a way that, when the fuel lever is moved away from the 'idling' position to the first step, the transmission as a whole is switched on. Thus, the driver need operate only a single lever and can devote his undivided attention to the track and the signals. With this arrangement, remote control or multiple control of several locomotives can readily be adapted.

The direction of travel is reversed by means of the mechanical reversing gear equipping the Voith Turbo Transmission. This reversing gear may be operated only when the locomotive is at a standstill. By coupling the reversing sleeve alternately with the gear wheels (5) or (6), the power flows to the output shaft either via gear wheels (5/7) or via (3/4), (6/7). (See fig. 2).

Fig. 1 shows the tractive effort/speed curve of a Voith Turbo Transmission, type L 830 rU. In this graph, the tractive effort ratio Z/Zi is plotted against the speed ratio V/Vx.



Voith Turbo Transmission, type L 830 rU
Tractive effort/speed curve



Schematic diagram
Voith-Turbo-Transmission type L830rU

Condensed Description of the Hydrodynamic Brake, type KB 510, as component of Voith Turbo Transmission, type L 830 rU

GENERAL

The hydrodynamic brake, which is normally built so as to be a component of the Voith Turbo Transmission, has been specifically developed for the braking of diesel-hydraulic locomotives.

When fitted in such rail vehicles, the hydrodynamic brake is used on level runs for deceleration over a maximum track speed range and for limiting the track speed on long down-hill gradients, in which case the hydrodynamic brake may be used to assist the conventional train braking system.

The maximum amount of energy which the hydrodynamic brake can absorb during braking is approximately equivalent to the tractive efforts developed by the Voith Turbo Transmission on uphill runs of the locomotive and is restricted by the power which can be handled by the output parts of the Turbo Transmission with which the hydrodynamic brake will be used, since, also during braking, the power is transmitted through these output parts.

GENERAL DESIGN

The general design of the hydrodynamic brake is based on the principle of the Froude brake, in which the energy is dissipated in eddy formation and heat (fig. 1). The rotor, which is of the double-entry type, is connected to the driving axles of the rail vehicle through the output parts of the Voith Turbo Transmission. The stator, which has 2 bladings to match the double-entry rotor, is rigidly connected to the brake casing, and so to the casing of the Turbo Transmission. The hydrodynamic brake is fitted with all controls and instruments required for adjustment of the different braking steps and supervision of the operation of the brake.

OPERATION

For operation the hydrodynamic brake is energized and de-energized by filling and emptying of its hydraulic circuit, a principle which have been most successfully applied in thousands of hydraulic power transmissions of Voith manufacture and which provides a smooth uninterrupted increase of the braking forces. As operating oil the hydrodynamic brake is supplied with oil from the sump of the Turbo Transmission, the filling pump of which delivers the oil into the oil circuit. For braking, the oil circulates in a closed circuit through the hydrodynamic brake and the heat exchanger, which is

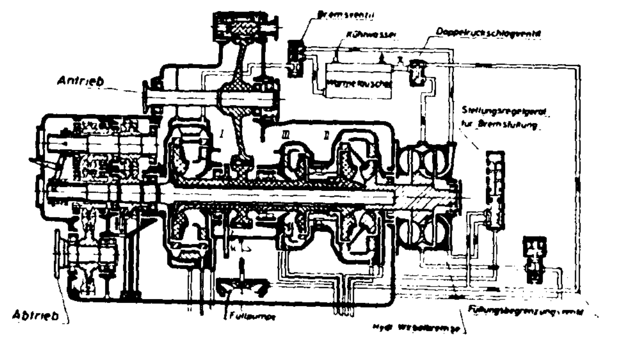


Fig. 1
Schematic Oil Circuit of Power Transmission and Hydrodynamic Brake

Antrieb	input
Abtrieb	output
Fullpumpe	filling pump
Hydr. Wirbelbremse	hydrodynamic brake
Fullungsbegrenzungs-ventil	filling-limiting valve
Stellungsregelgerat fur Bremsfullung	8-point filling regulator
Warmetauscher	heat exchanger
Bremsventil	braking valve
Doppelruckschlag-ventil	duplex non-return valve
Kuhlwasser	cooling water

required as standard accessory of the Voith Turbo Transmission and may be used for the operation of the hydrodynamic brake.

The heat developed in the hydrodynamic brake is transmitted by the heat exchanger to the engine cooling-water circuit. As, during braking, the diesel engine practically delivers no horsepower, the cooler, which is normally selected to meet the cooling requirements of both diesel engine and Turbo Transmission, may be used for cooling the operating oil of the hydrodynamic brake. An additional advantage of this arrangement is that the diesel engine is kept warm during down-hill runs of the rail vehicle.

The operation of the hydrodynamic brake may be gathered from the schematic diagram, fig. 1.

To energize the hydrodynamic brake it is filled by means of the filling pump of the Turbo Transmission via the open duplex non-return valve, the heat exchanger and the braking valve. At such time, the oil circulates in a short circuit consisting of brake—heat exchanger—brake, since the duplex non-return valve closes on completion of the filling of the hydrodynamic brake. This circuit constitutes the main circuit.

Diesel-hydraulic locomotive ML 4000 CC equipped with 2 Voith Turbo Transmissions, type L 830 rU, and attached hydrodynamic brake.

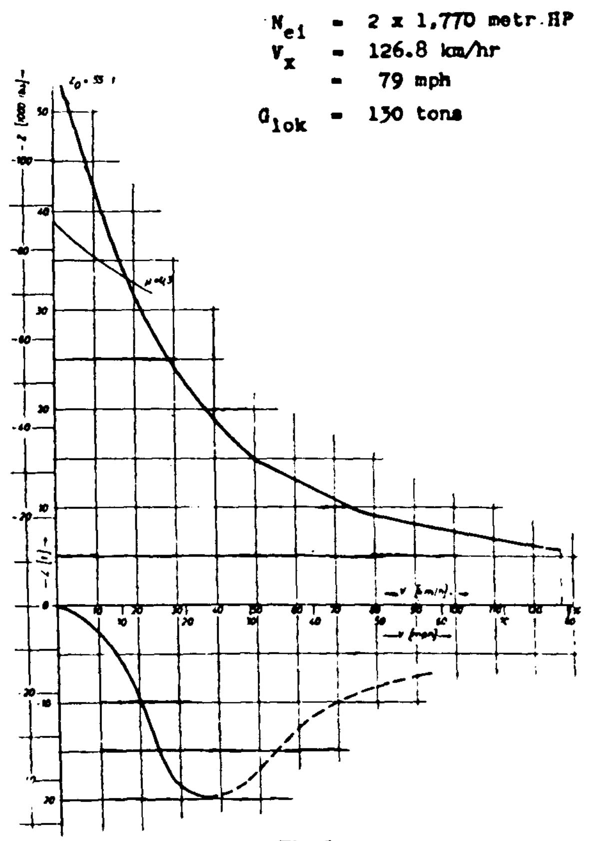
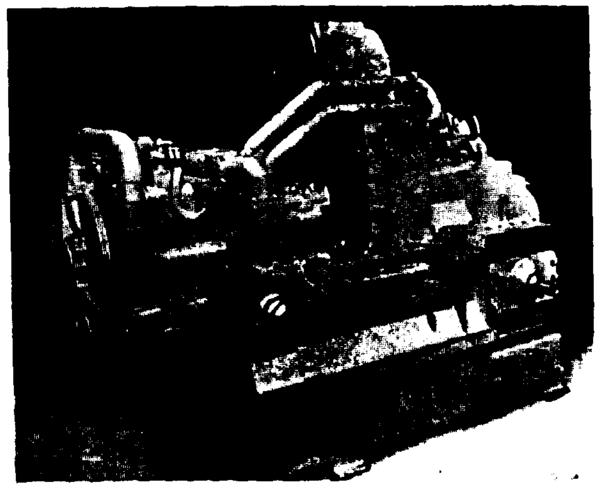
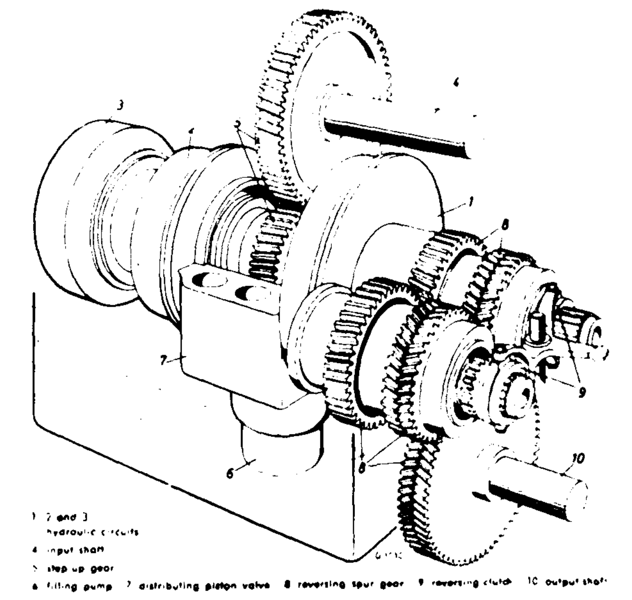


Fig. 2
Tractive Efforts and Braking Forces



Voith Turbo Transmission, type L 830 rU, with attached hydrodynamic brake (at the left)



The energy absorbed by the hydrodynamic brake can be adjusted by variation of the oil filling by means of a regulating valve which controls the cross-sectional areas of inlet and outlet of the hydrodynamic brake. This circuit constitutes a shunt circuit.

Since for heat dissipation and torque transmitting considerations the hydrodynamic brake can absorb

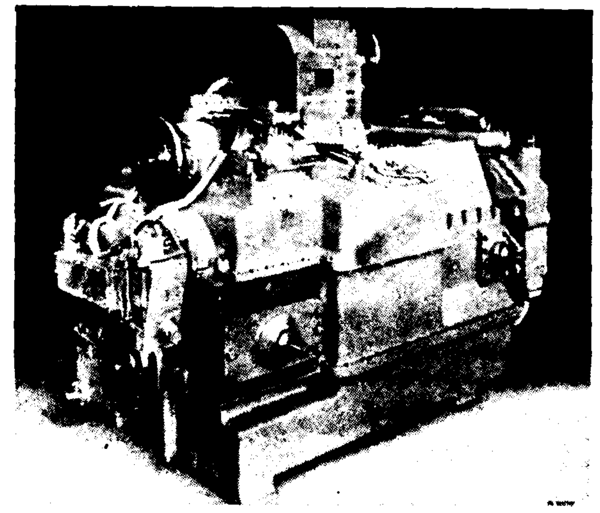
only a well-defined maximum amount of energy, a filling-limiting valve keeps the oil filling of the hydrodynamic brake within certain limits. This filling-limiting valve operates similarly as a relief valve : when the oil pressure in the hydrodynamic brake exceeds a preset maximum value, the surplus oil is allowed to escape.

From the filling-limiting valve and the outlet of the regulating valve the oil returns to the oil sump of the Turbo Transmission. Regulation down to the maximum capacity of the hydrodynamic brake is fully automatic, while the energy absorbed by the hydrodynamic brake is controlled by an 8-point filling regulator providing 8 different braking steps.

BRAKING DIAGRAM

Fig. 2 shows both the tractive efforts and the braking forces of a 4,000 metr. HP diesel-hydraulic locomotive equipped with 2 Voith Turbo Transmissions, type L 830 rU, with attached hydrodynamic brake. The braking curve consists of 2 different portions : a parabola which begins at the origin of the coordinates and a hyperbola in the range of higher track speeds.

Also the hydrodynamic brake follows the general hydrodynamic laws : at a given filling the brake torque is proportional to the square of the braking speed. Thus, the brake torque plotted against the track speed is a parabola which begins at the origin of the coordinates and intersects the hyperbola at a certain track speed. The parabola applies to the condition which prevail with the hydrodynamic brake completely filled, while the hyperbola represents the available forces which are limited in line with the maximum power which the Turbo Transmission can handle.



Voith Turbo Transmission L830 rU with attached hydrodynamic brake ; upper left : input, bottom left : output, extreme right : hydrodynamic brake

---

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.

* * *

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.

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.

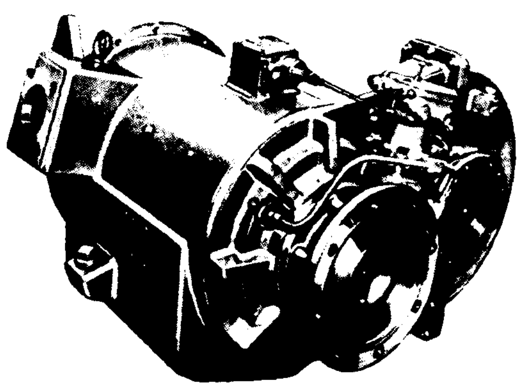
COMPOUNDING GEARBOX

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

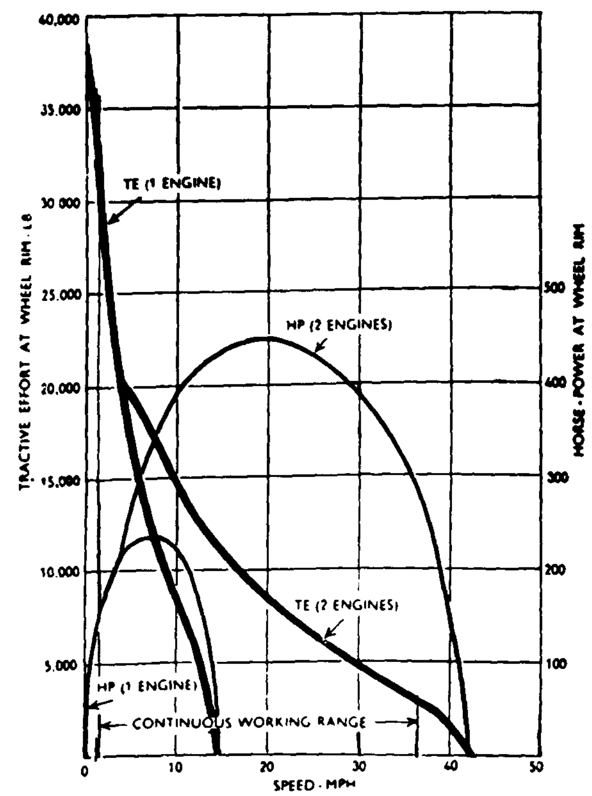
Taurus diesel-hydraulic 58-ton locomotive built by Yorkshire Engine Company, Ltd., in which is used the Rolls-Royce Type S transmission

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



←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.*

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.

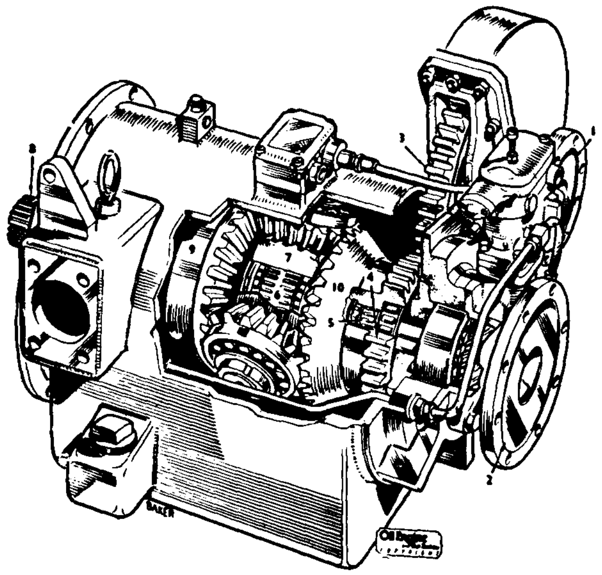
A second sprag clutch is incorporated between the differential spider and the output shaft, the function of which is to act as a free wheel to prevent the differential from being overspeeded during overrun.

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



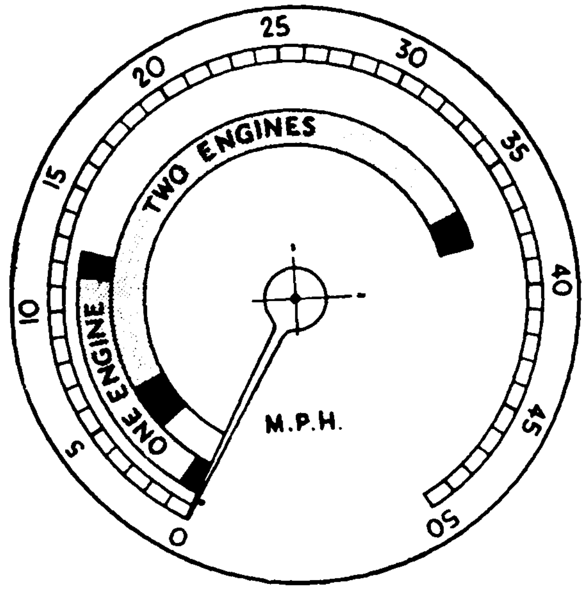
The Power Distribution Centre

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.

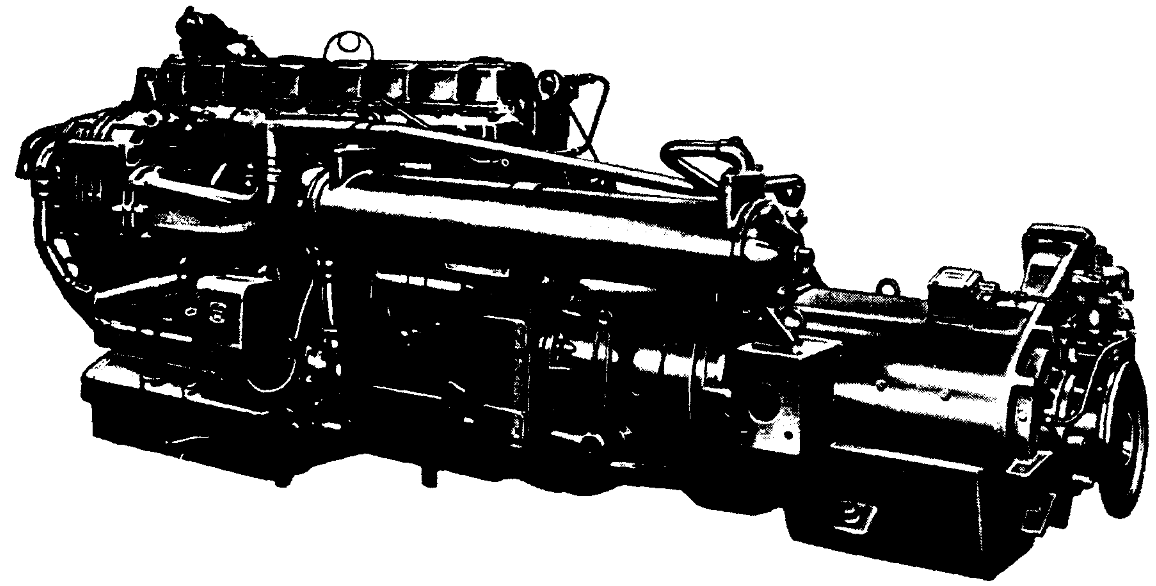
Positive lubrication of the compounding differential gearbox is ensured by a gear-type oil pump driven from No. 1 input shaft, with the exception that No. 2 input shaft bearings are splash lubricated. The differential gears, all hardened and ground, are Zerol spiral bevels.

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.

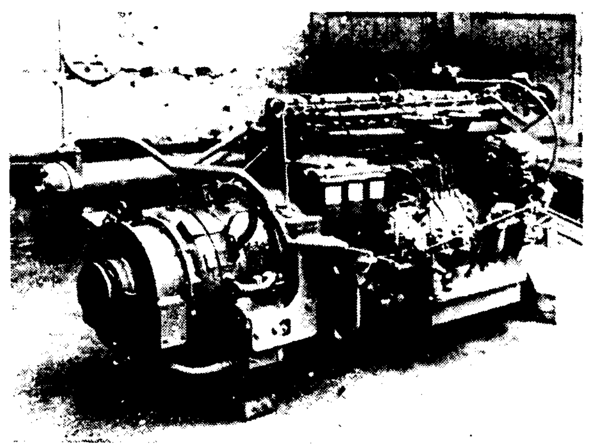
Using only one engine to give the maximum tractive effort means that the engine is running at a speed at which its specific fuel consumption is low while the efficiency of its torque converter is high. Weight of the power equipment is about 5 tons per power pack, or 16—18 lb. per horse power. The use 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.*]

New Appointments at Crompton Parkinson

Mr. A. S. Duncan, Director and General Manager of the Young Accumulator Company Ltd., Newport (an associate Company of Crompton Parkinson Ltd.) is leaving early in the New Year for India. He is to take up a senior position in connection with Crompton Parkinson's interests in that country. Mr. Duncan has been 21 years with the Company, the last seven of which he has been General Manager at Newport.

Mr. Duncan will be succeeded at Newport, by Mr. W. G. Nevill where the latter was his assistant from 1957–1961. Since March, 1961, Mr. Nevill has been special Assistant to the Managing Director in charge of the Cables, Batteries and Stud Welding Division at C.P.'s London Office. Mr. Nevill was at Cambridge University from 1947–50 where he obtained an honours degree in the Mechanical Science Tripos. He took his M.A. in 1955.

New Sources of Locomotive Power*

R. M. Coultas
Manager, Domestic Locomotive Sales
Locomotive and Car Equipment Department Erie, Pa.

IN discussing the sublect of new sources of locomotive power, two view-points must be considered: (1) What is the state of the technology involved? (2) What are the economic factors?

At present, the diesel-powered locomotive with an electric transmission has reached a high state of development and can, without doubt, be considered the standard motive power in this country — perhaps, throughout the world. The technology involved is well advanced. With the source of electric power used to drive the motors — the engine generator set — priced at about $ 40 per kilowatt, any other power source has a formidable economic obstacle to overcome.

Yet we manufacturers and you railroaders cannot sit back, relax, and say "The millenium is here. At last we have the ultimate source of locomotive power." (This in spite of what some advertisments might lead you to believe.) No! Railroad mergers, competitive pressures, and technological improvements all tend to increase the density of traffic on a given set of rails thereby putting increased premium on high horsepower, greater reliability, and — ultimately, further developments in the field of automation.

These three needs tend, In some respects, to be mutually incompatible. For instance, I am sure you are well aware that an engine which has proved to be highly reliable at a certain horsepower rating may not perform as well when the rating is stepped up. Yet automation, if you assume it to include a very limited crew or no crew at all, requires an even high degree of reliability than is necessary in today's locomotives with their normal two-man engine crew. Therefore we face the dual problem of increasing both reliability and rating.

Another problem concerns the technology of the turbo-supercharged diesel engine. When engines of a physical size customarily used in locomotives reach a rating of about 3800 gas horsepower, the useful power output at the crankshaft, the output power of the turbocharger turbine, and input shaft power of the compressor are all approximately equal. The question then arises as to where the useful power can best be

Mr. R. M. Coultas

extracted from the engine. Should it be taken from the crankshaft in the conventional manner or should the output of the turbine be used to drive the locomotive axles? The idea of driving the axles directly from the turbine has attractive aspects. For one thing, it is straightforward and simple in concept. Energy, transformation takes place only twice; first from chemical energy of the fuel to kinetic energy of the hot gas, then to mechanical energy at the wheels. By eliminating the extra steps of converting to electrical or hydraulic energy and back again to mechanical energy, efficiency can be increased approximately 15 per cent. In fact, the transmission in the ordinary sense has been practically eliminated.

* Paper presented at the AAR-ARF Research Seminar for Railroad Personnel held at the Sheraton Towers Hotel, Chicago, Illinois, November 2-3, 1961.

A locomotive constructed to this cyclic configuration has been built by Gotaverken in Sweden and operated by the Swedish State Railways. Its size (1350 gas horsepower engine output) is too small for use on U. S. railroads, but it illustrates the feasibility of such a design.

In considering the extrapolation of this gas producer-gas turbine locomotive to U. S. railroading, let us look at a 4-axle unit with a loading of 65,000 pounds per axle. A direct-drive gas turbine has 2 to 1 ratio between peak efficiency torque and stalled torque. In locomotive parlance this would be called a 2 to 1 wraparound. If we consider 30 per cent adhesion as the limiting starting condition, the minimum power level at which the 2 to 1 wraparound becomes practical on a locomotive with 65,000-pound axle loading is 800 horsepower input per axle. Thus a 4-axle locomotive requires 3200 turbine output horse power or about 3800 horsepower from the gas producer. This is within the practical range of development of present locomotive diesel engines.

An analysis of the gas-producer cycle indicates that the most promising path of development is that of evolution from the diesel engine to a crankshaft driven compressor gas producer. Other forms of gas producer are not competitive in either thermal efficiency or reliability.

The problems involved in developing such a locomotive to the level of reliability necessary for successful U. S. mainline freight service are many and difficult. They appear, however, to be problems of hardware development and do not require any breakthrough in the fields of either thermodynamics or metallurgy.

Current economic and technological factors do not favour further development of the gas turbine-electric locomotive for general use. Where conditions are suited to its characteristics, however, it has a field of usefulness.

One of the problems that has been particularly troublesome to those who tried to burn coal in a gas turbine has been the presence of fly-ash in the gas. This caused rapid erosion of the turbine parts. A new scheme for overcoming this problem is to dissolve the coal in an appropriate hydrocarbon solvent. The ash content does not dissolve and is filtered off. After this the remaining solution is reprecipitated as pure coal, fine as flour, and containing zero per cent ash. This should make an admirable fuel for a gas turbine, and — possibly a diesel engine.

All this extra treatment of the fuel would make the scheme decidedly uneconomical if it were not for the fact that some of the "low boilers" found in coal are not reprecipitated but are distilled off and can be sold at quite a handsome price, thus making the ash-free coal reasonably competitive. This scheme might prove quite attractive to railroads having extensive soft coal holdings, and we are watching it with interest.

Atomic energy continues to be discussed from time to time as a source of locomotive power. At present, however, the economic and technological factors, are still beyond a practical solution, and they may very well stay that way for the foreseeable future.

Some proponents of putting atomic energy onto a locomotive point to the once-being-developed atomic aircraft engine and say "If atomic energy can power a plane, why can't it power a locomotive?" Apparently, the fact was not too well known that only the crew's compartment on the plane would be shielded, and that the power plant would be completely unshielded. To avoid spreading radiation around the countryside at low altitudes, the plane would use a conventional power plant to land and take off, and would fire up the nuclear engine only when at several tens of thousands of feet altitude.

A nuclear-powered locomotive would have to be completely shielded. It cannot take refuge at high altitude, but must run through towns and cities. In general, we tend to agree with Dr. Edward Teller who stated that he regards the application of a nuclear power plant to a locomotive as "a most ingenious solution of the question how to combine minimum utility with maximum danger." Regardless of the hazards of such an application, the cost of the power plant and the cost of the fuel are both far in excess of corresponding figures for today's diesel-electric power plant. Most of the proposed nuclear plants for locomotives also involve several energy conversions with several percent loss in each conversion. This would make nuclear energy still less competitive.

Atomic submarines, such as the Nautilus, also have the problem of shielding. In this case the freedom from the need for frequent refuelling and the consequent great increase in radius of action far outweigh the drawbacks so far as military considerations are concerned. The submarine, incidentally, can have adequate shielding because of its size and form factors. A locomotive, restricted to smaller physical dimensions would present a much more difficult problem in shielding without getting into excessive weights for the power involved.

Another energy source potentially applicable to locomotives is the fuel cell, now becoming more commonly known as the fuel battery. This is a device somewhat similar to a conventional battery with each cell having an anode, a cathode, and an electrolyte and producing electric power. The fuel battery, however, is continually recharged with a conventional fuel, whereas the storage battery is intermittently recharged with electric energy to reverse the chemical reaction.

The fuel cells which are furthest advanced in engineering development today use hydrogen as the fuel. At the present moment it appears likely that this type will continue to dominate the field for considerable time to come, but in a field as new as this anything can happen.

A tremendous incentive exists to use hydrocarbon fuels directly in the fuel battery, since only with such a fuel can the full potential to generate electrical energy at low cost be realized. But in spite of this interest, it appears that the development will take a long time.

Present estimates indicate that hydrocarbon sources can provide hydrogen fuel at lowest cost in installations above 1000 kw capacity.

In both the steam reforming and partial oxidation processes of extracting hydrogen from liquid hydrocarbons the product is mixed with some sulfur compounds which are known to be poisons for many catalysts. Moreover, carbon monoxide is formed which, on subsequent oxidation to carbon dioxide, fouls the electrotype. While these impurities may be removed from the hydrogen, the added complexity and volume of equipment make the hydrocarbon processes completely unsuitable for locomotive applications where the hydrogen generating apparatus should be carried aboard the unit for most practical utilization.

Another aspect, and one about which nothing has been said, is that of the safety hazards associated with hydrogen.

One of the virtues of the fuel battery pointed out by its proponents is the fact that, unlike all heat engines, it is not limited in theoretical efficiency by the Carnot cycle, and its practical efficiency lies in the 60 to 80 per cent range. A point often forgotten, however, is that if hydrogen must be made, the Carnot cycle efficiency does apply, because this is a heat process.

In making a survey of possible locomotive power sources, cognizance must also be taken of some of the more exotic means of producing electricity. Both thermo-electric and thermionic devices have demonstrated a practical means of generation, though they are available only in very low power ratings and are presently of interest only to satellite builders. The magnetohydrodynamic means is only in its infancy in the laboratory. All of these have fantastic costs on a per-kilowatt basis.

Brief mention has previously been made of a transmission type, in connection with the diesel gas-producer-turbine drive. As U. S. made high-speed engines for trucks continue to grow in size—and they are growing quite fast at the moment—we feel that American hydraulic transmission development may be pushed into large sizes which could be practically applicable at least to small locomotives. What their reliability and maintenance cost in railroad service will be remains unknown. Certainly, the Krauss-Maffei locomotives with hydraulic transmission, soon to be running in the Western U. S., will offer all of us, both manufacturers and railroaders, an opportunity to study the problems and performance of hydraulic transmissions under American operating conditions.

To repeat what was stated at the beginning of this talk, any new source of locomotive power must meet the criteria necessary to achieve progress in the railroad field—more horsepower, greater reliability, and adaptability to more extensive automation. Curiously enough, the power source that today—and for the forseeable future—best meets these criteria is the second oldest in the railroad history—electricity, delivered to the locomotive from a wayside generating station via an overhead system.

Far higher horsepower per unit can be achieved because of the elimination of the need for each locomotive to carry its own power plant. Yet diversity of loading means that the required central station capacity need not be as large as the sum of the diesel power plants it replaces. Reliability is greatly improved by virtue of the very nature of large central station generating apparatus. And certainly, nothing will lend itself to automation more readily than an electric locomotive which has no diesel engine with its many auxiliary system, to be watched and tended.

The silicon rectifier, just beginning to be used in railroad electrification, offers several advantages over the currently common mercury-arc rectifier. Because the former needs no firing circuit, the allied circuit complexity is reduced. Because it can operate at a high temperature, air cooling is satisfactory and the cooling water system associated with the mercury-arc rectifier can be eliminated. Over-all efficiency is also slightly higher for the silicon rectifier.

Considerable progress has been made over the last several years in the art of reducing the susceptibility of communication circuits to trolley-rail currents. This means that any new electrification can be at the standard commercial 60-cycle frequency. Because of the vast size of today's power networks, it would seem reasonable that in most parts of the country the single-phase load resulting from railroad electrification would not cause harmful unbalance even at peak hours. Thus separate railroad power plants or phase conversion equipment would not be required, and favorable power rates could be expected.

In many respects, both the nuclear power plant and the fuel battery power plant would lend themselves very readily to electrified railroading. They could be placed in wayside stations at appropriate intervals, where any health and safety hazards could be carefully controlled and where efficiency would not be unduly penalized either by the necessity of keeping the unit within certain weight and dimensional limits or by the artificially small output dictated by the limited ability of a given locomotive unit to absorb power.

All of today's applications of nuclear energy power sources involve eventual powering of a turbine, which can produce alternating or direct current power for running the railroad.

A somewhat different situation exists with the fuel battery, however. This is a direct current source. Fundamentally, then it offers the possibility of a multiplicity of cells connected in series to form a high-voltage fuel battery which delivers direct current to the catenary, to be utilized by direct-current motors on the locomotive (the simplest kind of locomotive). This might be a very attractive means of operating a railroad from the standpoint of both reliability and efficiency, since a minimum of energy conversions is involved. The fact that the larger the installation the lower both the first cost and operating cost per kilowatt, lends even more credence to this possibility.

Until the economic picture changes sufficiently to justify electrification, either through increasing traffic density or relative changes in energy costs, the diesel-electric locomotive will remain the prime source of railroad power. Even here, many of the benefits of electrification can be achieved with high horsepower-per-axle units having a minimum of complexity and a built-in freedom from the biggest hazard of all—dirt.

The advances in design will bring maintenance costs down from the present level of the conventional locomotive, though—since the diesel engine is still present—they can hardly hope to approach those of a straight electric locomotive.

Whatever direction further developments may take, we can be sure that locomotives of the future will make a major contribution to increased economy of railroad operation and improved service to the shippers.

The railroads are changing to meet the altered conditions and new demands now facing them. They are experiencing a resurgence of capability which will make them an increasingly vital factor in our ever-expanding economy.

All of us connected with this great industry face the future with the knowledge that it presents a challenge and opportunity for technological progress that may well revolutionize railroad motive power.

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.

Purchase of 125 Diesel Locos for Indian Railways

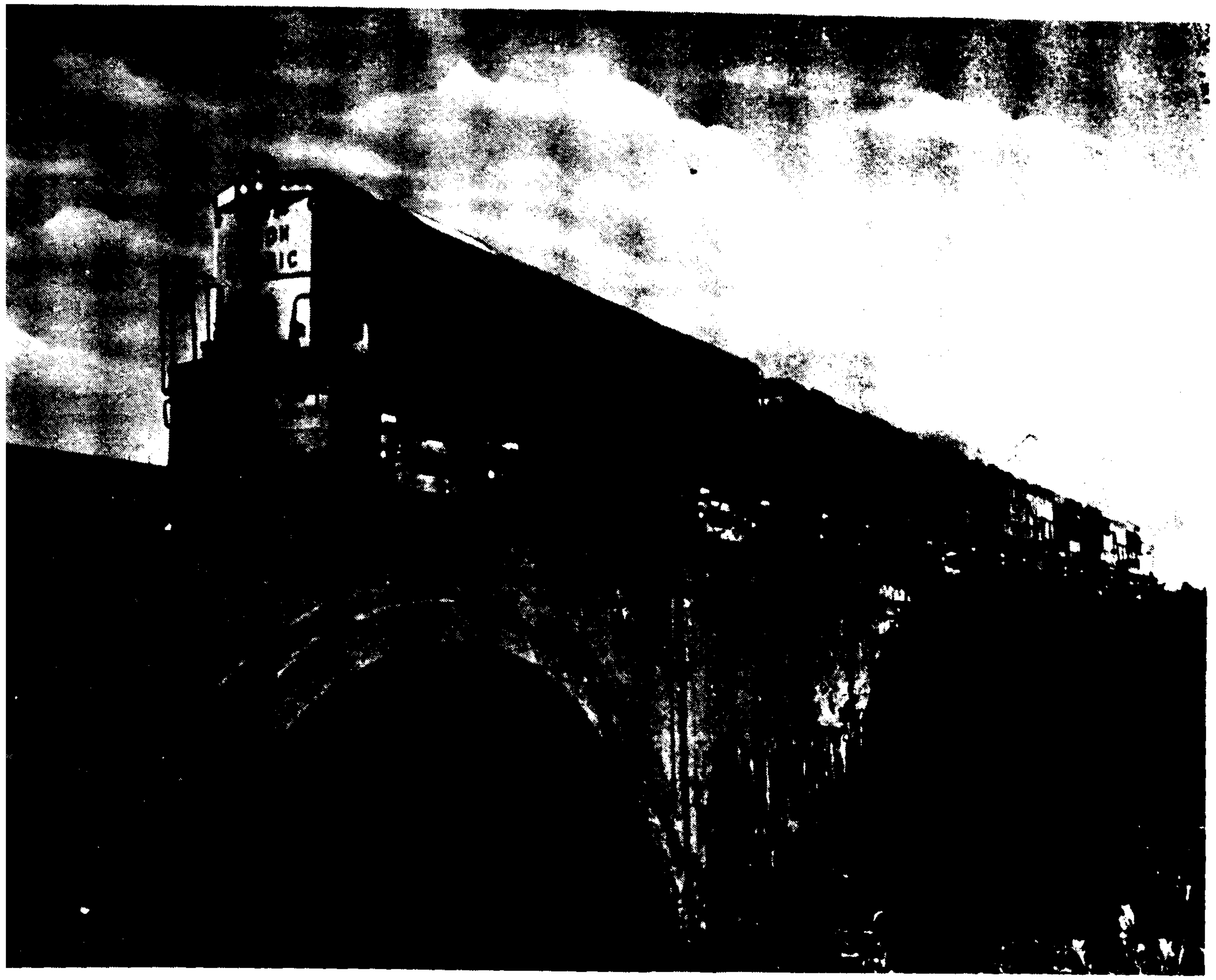
The U. S. Government will provide foreign exchange to India for the purchase of 125 diesel locomotives for the Indian railways, the U.S. Ambassador, Mr. John Kenneth Galbraith, announced in New Delhi.

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.



New Motive Power

Four of the newest locomotives in the Union Pacific Railroad's motive-power fleet – 2500-horsepower General Electric (U.S.A.) U25B units – shown ready for delivery from the builder's plant at Erie, Pennsylvania. In addition to the four units delivered to the Union Pacific, G-E has sold eight U25B's to both the St. Louis-San Francisco Railway (Frisco) and to the Atchison, Topeka and Santa Fe Railway System. The four-motor four-axle locomotive, powered by G-E's FDL-16 diesel engine, is designed for heavy drag [illegible]speed freight service.

Signalling & Telecommunications Supplement

V.H.F. Multichannel Communications

*By T. S. Rajagopalan**

THE greatest single contributing factor to the remarkable progress which this age is experiencing has been widening of our horizons due to rapid means of transport, ever extending road, rail and air systems. For business purposes, international trade, efficient administration of large scale organisations, and good government, means of rapid contact between people are absolutely essential.

Until recently such communication was possible with open wire lines and underground cables with or without carrier systems, or by Radio high frequency circuits. An open wire system has got great disadvantages, for it requires many skilled as well as semi-skilled personnel for maintaining the system efficiently under all climatic conditions and necessitates frequent change in poles and lines etc. The H.F. communication has several limitations as the number of channels which can be carried is small, reliable communication cannot be guaranteed throughout the day and year, the band is very crowded and interference on the frequency can be from any part of the world.

During the last decade a new means of communication, viz., V.H.F., Multichannel system have come into practice. With only a few repeater stations in between, long distance can be bridged for communication purposes with a large number of telephone and telegraph channels.

For communication systems fulfilling large traffic requirements, even very occasional failure of circuits would result in large loss of revenue and great inconvenience. Therefore identical equipments can be provided, in parallel, as a standby and will operate automatically. Needless to say, that the standby link can also be made to carry traffic when extra channels are required than those provided by the main equipment. In a rapidly expanding industrial economy, provision for growth of such valuable communication systems need not be emphasised.

The HM 100 series of Terminal stations and HM 150 series of Repeater stations are capable of carrying upto 48 high grade telephone channels and are in production in BEL. Each telephone channel can accommodate 24 teleprinter channels. With one such teleprinter channel, at an average speed of 35 words per minute one could transmit some 50,000 words within 8 hours which is equivalent to same 2 or 3 complete newspapers.

Places which are separated by rivers, back waters, marshy areas and mountainous terrain where open wire lines are difficult to install and maintain, the VHF., multichannel communication plays an important part for reliable two way communications.

For Oil Pipelines running long distances between the oil fields and the Refineries in difficult uninhabited terrain VHF., multichannel plays an important part for telecommunication and telemetering purposes. The Control Room receives the information from all the slave stations on the principle of 'Cyclic Interrogation' over individual communication channels. Each of the channels occupy one telegraph channel and the digital information obtained are logged on electrical typewriters or displayed by projection 'In-Line' indicators and warning lights. This system enables the operation of selected relays at the outstations which in turn increase or decrease pumping speed and monitor the precise tank level and temperature.

The main advantages of VHF., Multichannel from the maintenance Engineers point of view are :

(1) There is no need to maintain pole and wires through rugged inaccessible country.

(2) There is no possibility of interruption of communication due to brake-down in lines due to bad weather.

(3) Whatever little possibility of interruption of communication is narrowed down to a few fixed points instead of many miles of line or cables.

(4) Routine preventive maintenance can almost eliminate the possibility of failure as no break-down or unpredictable factors are involved.

* Junior Engineer, Bharat Electronics Ltd., Bangalore.

(5) Stations can be normally sited at places which are already accessible by vehicles and occasional inspection by a handful of skilled personnel is sufficient.

(6) The installation of the system is much more rapid than of lines or cables for the reasons pointed above.

(7) Long term operating costs compare very favourably with those of line or cable systems of similar capacity.

(8) By using directional Aerials of high gain and sharp directivity and with smaller output, transmitter interference on the channels are avoided.

(9) Two way both telephone and telegraphic channels can be worked very efficiently simultaneously.

Stations which are far away and are to be connected by Multichannel systems, can be engineered by interposing repeater stations in the route, at intervals, to amplify the signals. At any intermediate points where more number of channels are required to be dropped and reintroduced this can be done efficiently with Back-to-Back Terminal stations. At any intermediate station where only one or two channels are to be dropped and introduced this can be done with the normal through Repeater equipment itself.

These special advantages of V.H.F. Multichannel systems have been made use of in many tropical countries where access to various corners of these territories is impossible by road.

However it must be pointed out here that this system is more economical as larger number of channels are utilised. Large scale VHF., Multichannel systems are in operation in tropical countries like Nigeria, Ghana, Malaya, Persia, East Africa, Rhodesia etc., and cold countries like Iceland, Norway, Sweden, Great Britain etc.

BEL have gained large amount of experience over the past few years in planning of such communication systems, in carrying out actual radio propagation survey in order to economise the initial outlay, instal the entire systems inclusive of aerial towers, channelling equipments, power plants and other associated equipments. Specialised instruction and training of personnel to carry out routine maintenance of these systems can be undertaken as well.

A V.H.F. Multichannel scheme with HM. 100 and HM.150 series will be commissioned very shortly for the South Eastern Railways with Garden Reach, Khargpur, Tatanagar, Adra and Chakradharpur as terminal stations and Kolaghat, Jhargram and Dalma Hills as repeater stations.

The channelling equipment is meant for use over broad band VHF., radio link upto a maximum of 48 speech channels by combining them to form a single carrier signal suitable for modulating the above VHF., equipment and demodulating and separating them into the different speech channels.

Initially the channelling equipments are equipped with 12 VF., Channels and 12 VFT., channels providing facilities for extension to the ultimate capacity by adding channel units from time to time.

The main Radio equipment is provided with standby and automatic changeover equipments at each of the stations such that in case of failure or deterioration of performance to a predetermined level, of the working equipment, the standby will automatically come into operation. The change over will be such that there is practically no interruption to any traffic in commission either on the speech channel or the voice frequency telegraph channels.

An EOW (Engineers Order Wire) for communication between each of the terminal and repeater stations are also provided in addition and apart from the traffic channels available through the channelling equipment.

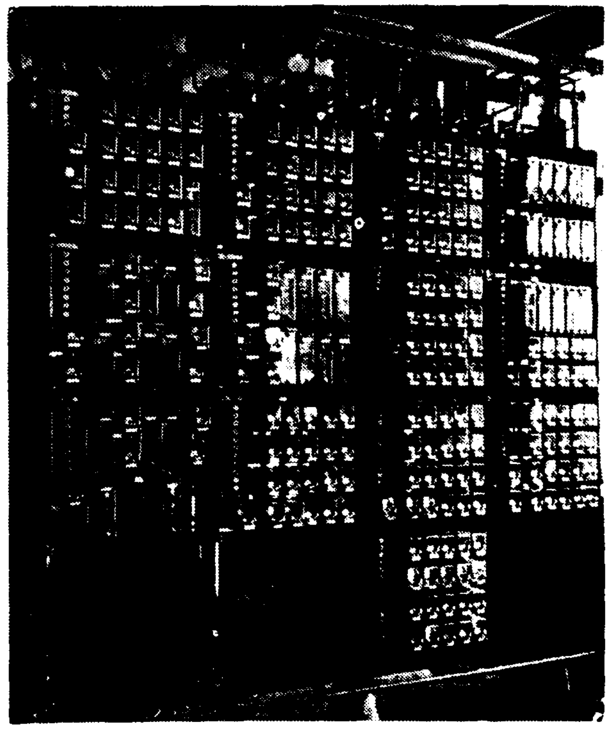
It may thus be seen that Radio Multichannel Telephone Systems can provide main telephone trunk networks at reasonable cost in addition to a very high reliability.

Railway Signalling and Safety Equipment from the GDR

By H. Schneider
Engineer

A GROUP of experts of the Works for Railway Signalling and Safety Installations of the GDR is at present touring India in order to acquaint Indian experts and interested persons with their products which can be supplied against payment in Indian Rupees. A complete diagram-operated interlocking installation was on view in New Delhi from June 26 to July 10, which demonstrated the functioning of the various equipments. The exhibition was arranged in co-operation with the Indian Railway Board. The opening ceremony at Baroda House, New Delhi, was attended by the General Manager of Northern Railway and a great number of Indian experts and interested persons. The installations of the Works are exported by the GDR foreign trade enterprise "DIA Elektrotechnik" in the framework of the Trade Agreement between India and the German Democratic Republic.

During the last hundred years or so the signalling and safety technique has developed from the most simple mechanical equipment to the present most up-to-date diagram-operated interlocking installation. The present signalling technique, however, does not restrict itself to the safety of railway traffic on the stations and the line against collisions, but also serves the centralisation and stricter control of all railway operations.



Relay racks in the relay room

By modern signalling installations the effective capacity of railway routes and the efficiency of railway stations as well as the safety of traffic are continuously increased. The following passages shall give you a general idea of the latest type of diagram-operated interlocking installations as they are constructed and installed by "VEB Werk fuer Signal and Sicherungstechnik Berlin". The definition Diagram-Operated Interlocking Installation implies that the actuating devices for switches, signals and the establishment of routes are positioned on a track diagram which reproduces the position of all tracks, switches and signals in a most realistic manner. It also contains keys and control installations for rails, switches, signals and power supply. The route of a train through a station is marked by illumination of the rails. Moreover all occupied rails as well as the position of all switches and signals are indicated by coloured illumination. The operator is thus able to follow all traffic operations at any time.

The pulling of two keys is enough to establish, safeguard and clear the route of a train through the station. All switches on the route are automatically brought into the right position. Switches of adjoining track sections lying on the route are set so as to exclude flank collisions. Faults in the technical equipment such as switches, tracks or signals are indicated to the switch operator by automatic alarm flash-lights.

The establishment of a route takes but a few seconds. Taking into consideration the huge amount of human labour and time which was formerly required to operate the old mechanical switch installations, one recognizes the great leap forward that rail safety technique has made. During the last ten years these installations have reached a high degree of perfection that guarantees maximum safety to rail-bound traffic.

The orders given by the track control table by pulling keys are conducted via cables to the switches and signals and from there back to the switch control table with the help of the relays room. A very precisely working control system guarantees the correct working of the relays dependent on each other and the switch installations.

Far-reaching standardisation warrants a quick assembly of these equipments for which the non-interchangeability is particularly important. Automatic test instruments see to it that eventual switch faults are eliminated during production so that only correctly switched standardized groups are supplied by the works.

Switch drives are adjusted to the various forms of switches at home and abroad. The drive for those switches where there are no particular blockings of the switch tongues are especially strong and reliable. Switches whose faces are passed by fast trains are equipped with an additional test equipment for supervising the correct position of the switch tongues.

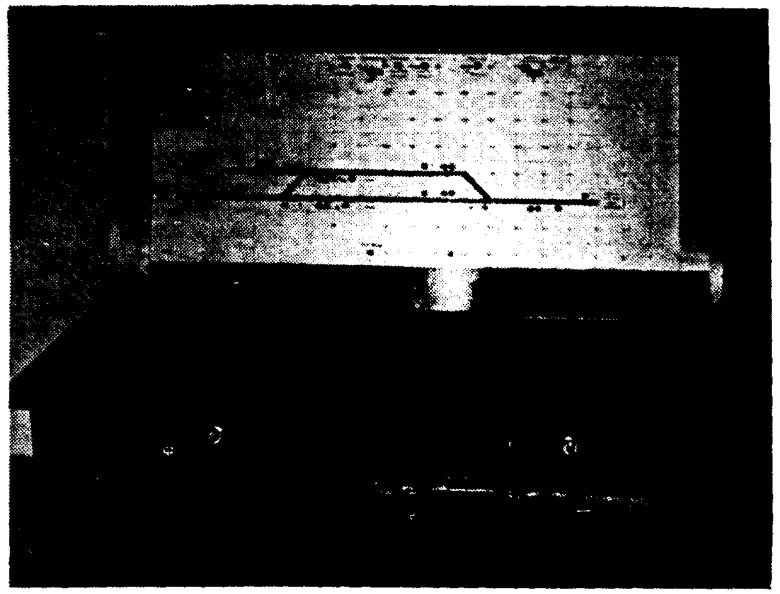


Diagram-operated track-control table

Triple signal lamp

Signals are also adjusted to the signalling systems of the different countries. The caution, wayleave, shunting and repeater signals are made according to local requirements.

The modern diagram-operated interlocking installations require a very efficient and reliable power supply. The power supply installations have the task of providing power from the main as well as of feeding power to the switch installations in case of failure of the main current. All necessary switch operations are automatic so that there can be no interruption and the safety of rail traffic is guaranteed.

In the same way as the safety of trains is warranted to a maximum possible extent in the stations, it is also guaranteed automatically on the routes between the stations. The emergency power supply installations provides the track blocking equipment with the necessary operating current and thus prevents any disturbance caused by eventual failure of main current.

For further simplification the track safety installations of several stations and tracks can be remotely controlled. In a similar way central dispatcher installations can supervise the situation of the switches of one or more tracks.

Train course and number recorders give further possibilities to the supervision and control personnel to control the entire course of operation more exactly and

replace at the same time a considerable number of workers.

Instruments of this kind are not only used in the railway system but also serve the supervision and following up of production processes and the situation of manufacture in industrial enterprises.

The steadily-growing goods transport necessitates a very quick formation of new goods trains on all junctions. In this field, too, automation has progressed to such a degree as reduces the entire course of operations to the minimum time.

Each of the many level crossings constitutes a certain danger both for rail and road traffic. The still existing mechanical level crossing gates are, therefore, being substituted by automatic single and double level crossing gates. The train controls not only the opening and closing of the crossing gates but also adjusts the time of the slowing down of the train's speed. Special control signals show the locomotive driver the proper working of the automatic installations.

The above mentioned railway signalling and safety installations are produced by the nationally-owned Works for Signal and Safety Installations in Berlin-Treptow in the German Democratic Republic. A proof of the excellent quality of the products is the fact that the Works produces these equipments not only for the railway system of the GDR but moreover, for Finland, Greece, Poland, Bulgaria, Czechoslovakia and Egypt where they have met with widespread appreciation.

[An Extract from : The Indian Railway Engineer, July 1961]

RAILWAY VHF AND MICROWAVE RADIO

By Brigadier E. J. H. Moppett, M. I. E. E.
PYE Telecommunications Limited

THE equipment and methods used for railway and radio communication are generally similar to the usage of other modern mobile and point-to-point services.

MOBILE RADIO

The mobile radio telephone for vehicular use in an inexpensive and easy-to-operate form is an important new tool that has become available to engineers since the war. Its introduction has led to increased efficiency of operation and substantial money saving out of all proportion to the cost of the radio equipment. The applications of radio telephones are basically similar in all engineering operations.

The first large scale application of wireless was to communication at sea. Since the early days, wireless telegraphy and later telephony have been applied by civil and military users to maintain contact with mobile units which otherwise would be out of touch. But general use of radio by vehicles in the automobile class had to await the full development of V. H. F. communications. V. H. F., that is Very High Frequency (higher than 30 megacycles, lower than 19 metres), has characteristics which make it most useful for this class of service. Transmission is effective from an aerial of small enough dimensions to be fitted without embarrassment to a vehicle. V. H. F. transmissions do not interfere with, or suffer interference from H. F. wireless communication circuits, standard broadcasting or television.

RAILWAY APPLICATIONS OF MOBILE RADIO

In the U. K. the railways use mobile radio for all applications corresponding to its employment by other users. Road collection and delivery, executive carsm dockyards, temporary engineering communications and emergency uses are typical applications which present no special problems. Due to the need to locate all equipment on railway property, ranges are often restricted below those of other users, as railways do not often have rights on high points. Often it will be economic for railways to rent access and lines to use higher ground and secure better coverage.

British Railways marshalling yard at Feltham, Middlesex, England

Mobile radio is used in modern yards for contact from box to shunting loco. The general employment of diesels has made the installation and use of radio easier through the availability of battery power and the cleaner conditions compared with the old steam plant.

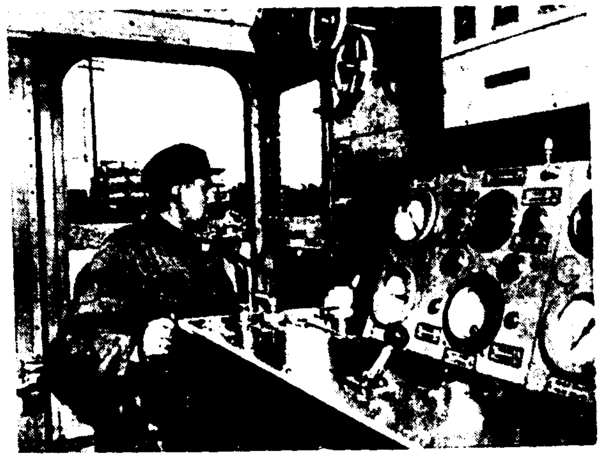
Communication by passengers in trains with ordinary telephone subscribers has been successfully demonstrated, employing a radio connection with the trial motorists radio telephone system in Lancashire, set up by the G. P. O. After the solution of payment problems, this application may be taken up when the G.P.O. have extended the coverage over a greater area.

No significant progress has yet been made in the U. K. in the application of radio telephone as a control aid for train operating. In the U. S. A. loco to box radio contact is in general use throughout all major systems. It is often thought that American railways operate over vast prairies using simple despatcher operation. This is not so... their main radio utilisation is in areas where methods and traffic density approximate to U.K. In railway operation the signalling system must be the paramount control. This principle is strictly observed in connection with railway radio in U. S. A. The radio supplements the signalling system to make it more effective and safer. A system runs to working time tables but to some degree these are always departed from as the day progresses. It is the task of the controllers and local controllers (signalmen) to restore schedule as much as possible. This calls for information and the best possible information comes from actual radio contact with the trains.

Track circuiting will give information to the extent that a section is known to be occupied, but whether by a train or not, and if the train is stationary, moving or in two or three sections is not known. If the information is given over the radio direct from the driver to the signal box consequent adjustments could be made more accurately than at present.

Radio can also make a contribution towards the reduction of accidents. The immediate radio report of an accident can prevent other trains running into wreckage; assistance can be called quickly, lives saved and normal working more rapidly restored.

Locomotive installation at the steelworks in England of Messrs. Steel, Peech & Tozer



Pye radio telephone installation in Belgian Railways

Obstructions on the line, permanent way hazards, uncoupling of goods trains can all be reported without delay and operation in fog or low visibility improved when signalmen and drivers can mutually check positions continuously and check that signals have been observed.

In the U. S. A. base radio stations, to contact trains, are disposed at intervals of 10 up to 40 miles along the track to maintain continuous coverage, according to topographical conditions. Normally these base stations are sited at conveniently situated signal boxes but not every box has a base station as these are sometimes connected by line in pairs, or groups, to one radio base station.

It is hoped that as the financial situation permits the use of mobile radio will increase on other railway systems. Already in England some shunting yards are controlled by radio and in Scotland radio has been fitted into some trains to assist when they become snowbound. Modernisation is an expensive process, but to introduce main line radio working would be one of the least costly of improvements and insignificant in comparison with the vast total expenditure.

POINT-TO-POINT RADIO SYSTEMS FOR RAILWAY USE

In many respects the radio methods for point-to-point working for other applications can be used for railways where corresponding ranges and capacities are involved. For many reasons H. F. communication is unsuitable and use is made of V. H. F., U. H. F. or Microwave Systems. All these can, in varying degrees, be made substantial directional beam systems.

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

(Continued from page 10)

V. H. F. is little used because the channels are largely taken up by mobile services of all kinds. Channels are available in the U. H. F. and microwave bands and the choice depends mainly on the number of channels required.

Point-to-point radio is always a replacement of, or, alternative to open wire or cable. It is not confined to the railway property for transmission path and calls for no engineering work except at terminals and at relay points. Whether to use radio depends on the balance of cost between the engineering work involved as well as between capital costs of rival systems. In evaluation it should be remembered that the maintenance cost of radio is higher but, on the other hand, radio is not affected by floods or landslides.

Line carrier systems with suitable ancillary equipment are suitable for radio links as well. For the full utilisation, however, of the higher circuit capacity of microwave equipment a more sophisticated carrier link is needed.

U. H. F. in the region of 450 Mc/s provides radio links on a multichannel basis. The equipment is fairly conventional and directional aerials are multi-rod yagis or corner reflectors. Hops of 20 to 30 miles are employed, according to the ground height available, with masts of up to 150 ft. on low ground and lower masts on hill tops. Repeating relays can be of the non-modulating type, requiring no carrier equipment at relay points, except where tee-offs are called for. Single channel U. H. F. links are sometimes used to connect mobile system base stations to control points.

Microwave systems available for railway use operate in the 6/7 Kmc/s band. They are suitable for 250 or more circuits. Parabolic aerials are used, again with towers of up to 150 ft. on lower ground. It is possible to use a vertically directed parabola on the ground, with a plane passive reflector at the top of the tower. Hops of up to 30 miles are possible with suitable topography. The repeating relays may demodulate to sub-carrier, or be fully non-demodulating, frequency changing type with more expensive equipment.

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. 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

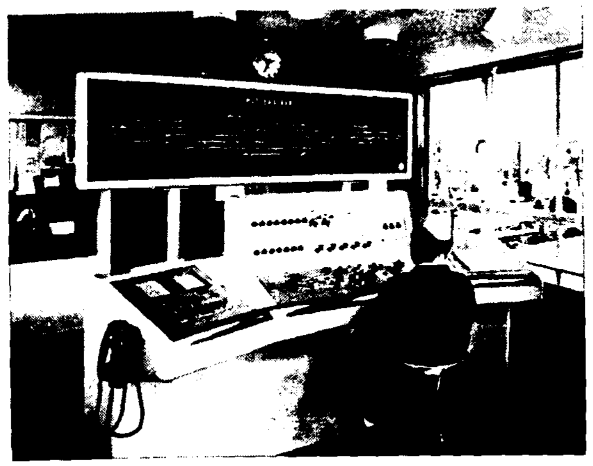
Power operation of points and signals has been used at the busiest junctions and stations in Britain since the 1900s, but was adopted in India only when big re-signalling schemes, such as those that accompanied electrification, were carried out. The type of signalling then introduced was largely of the 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, if successful, will doubtless be widely used as it speeds up single-line traffic by making it unnecessary to reduce speed through 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 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.



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.

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.

Permanent Way Engineering Supplement

THE EFFECT OF TAMPING WORK ON TIES

By Dipl. Ing. Egon Schubert
Austrian Federal Railway, Headquarters, Vienna.

THE condition of track and switches changes continually and not uniformly and therefore has to be corrected sooner or later according to the speed of traffic. The reason for these changes of track condition rest mainly in the different conditions of the ballast bed on the ground (different kinds of soil and changing humidity), also in the varying pressure on the track (different grade of vertical or horizontal pressures and blows). Additionally, the ballast bed sets itself, but this is comparatively small after an intense tamping work in comparison to the changes within the track formation. These settings of the track formation itself naturally influence unfavourably the track condition, but they are not the subject of this article.

To lessen the changes of the track formation effected by the pressure of the tie, possibilities exist either to establish a good track formation itself cr to lessen the specific pressure of the ballast on the track formation. The first can only be achieved with high cost, so that improvement can only be reached by a corresponding formation and packing of the ballast itself. It was formerly believed that the distribution of the pressure on a greater basis was guaranteed by an even higher ballast bed. In reality, the width of distribution is depending on the height of the ballast bed, on the material-parameter and on the relation of the horizontal to the vertical packing and also on the kind of strain. The greater the vertical packing comes to be in comparison to the horizontal packing and the bigger the blows are, the smaller will be the width of distribution.

During the tamping work the ballast underneath the tie is mostly only vertically packed and pre-stressed. The pressure of the tie condenses the ballast under tie to a larger degree than outside of this area. If therefore at the beginning the distribution of the pressure took place within the less condensed ballast this decreases later more and more.

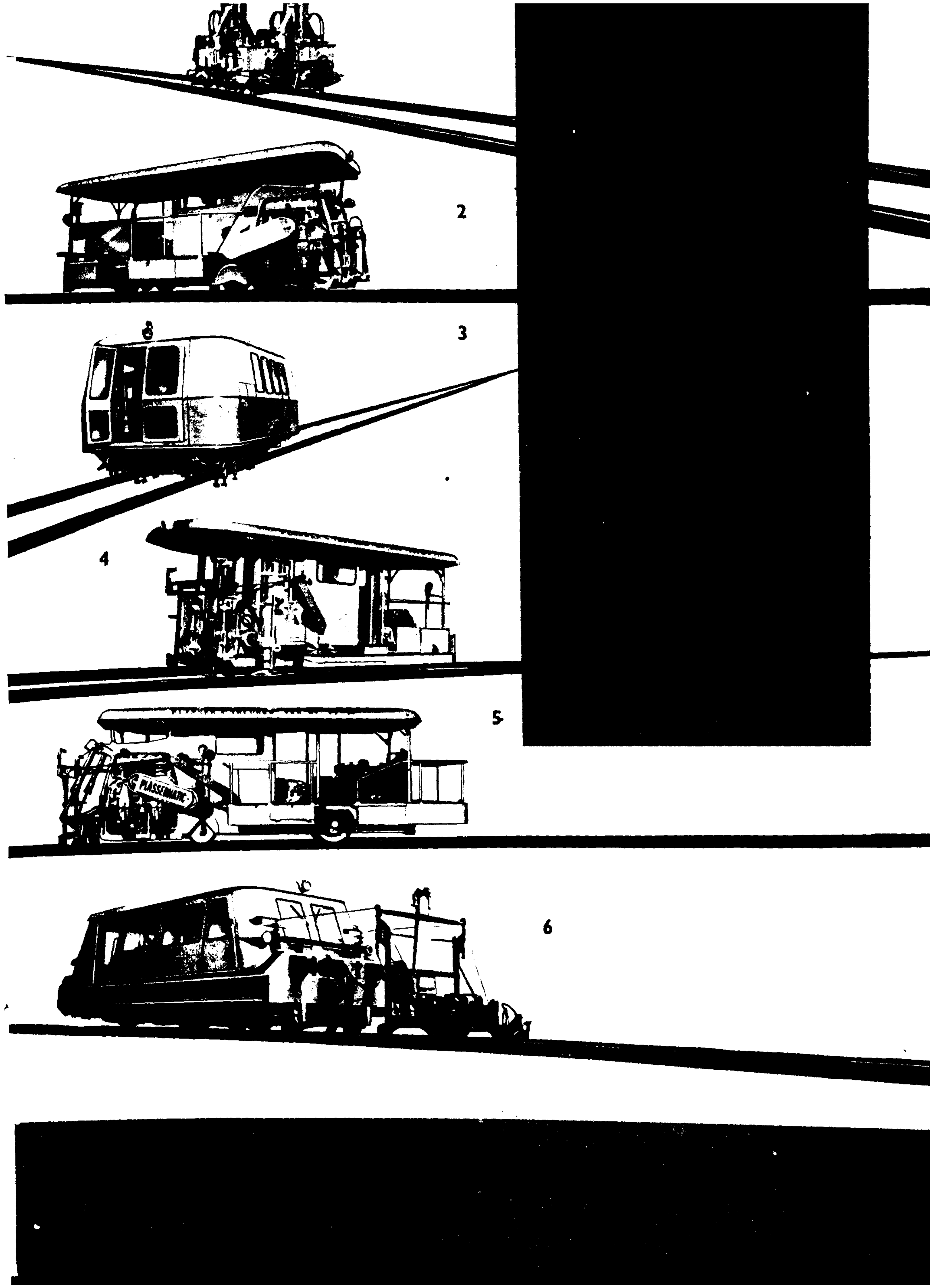
The term " blows " seems to be justified as the weight in form of a pressure increasing and decreasing within tenths of a second. The duration of the increase and decrease of the weight depends only on speed of the rolling wheels. But if the ballast bed underneath the tie is more condensed than the ballast right and left from it, then any pressure in form of blows will be spread over this more condensed area because of the better conductivity. For instance, shorter or narrower ties used instead of normal ties show after a short time greater settings with all the unfavourable symptoms (mud joints etc.) Or a rolled ballast bed has a better effect on the maintenance of a track with wooden ties, whereas in the concrete tie track the pressure distributing effect of the rolled ballast does not prevail because of the hard blows of the concrete ties. Acknowledging this situation a higher rolled ballast bed is demanded for concrete tie track. This has a strong horizontal packing and spanning and is therefore able to distribute the pressure sideways.

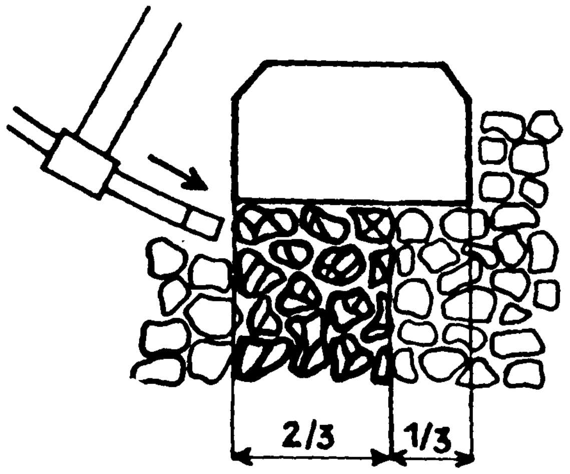
The correction of the cross level is effected by lifting and packing of the sunken track parts or of the whole track or by a measured bringing in of small ballast (Soufflage) into the track. The different methods will be discussed now in particular.

THE TAMPING BY HAND

First the track is lifted by a track-jack to a predermined measure, then the existing ballast bed is loosened for better condensing of the ballast, afterwards additional ballast is brought in and then the ballast stones are tamped under the tie and finally even every stone for itself, until no more can be brought in by normal pressure. By this tamping work a condensing under the tie like in picture no. 1 is achieved. Considering the direction of tamping and also the relation of the ballast to the shoulder a condensing is achieved only under the tie itself, the condensed part in the ballast bed will not get broader downwards.

When now pressure is put on the tie after the first tamping work, then the whole pressure is conducted over the condensed ballast bed to the track formation. The static pressure cannot distribute itself sideways





← *not condensed*

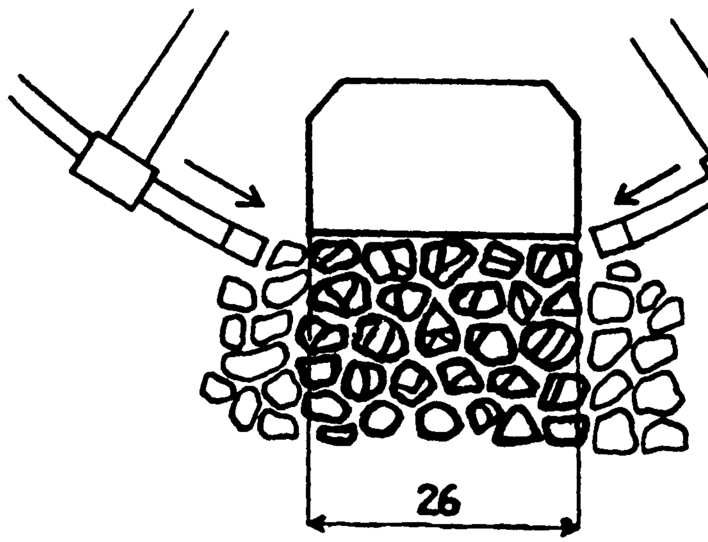
Picture No. 1

Condensed

because in condensed ballast the pressure is deducted faster as in the non-condensed ballast bed according to the slight form-alteration. A pressure in form of continuous blows seeks far more to find the shortest way of pressure transmission than a static pressure. Within a time unit the pressure in condensed ballast covers a far greater way as in a not condensed or lesser condensed ballast bed. Therefore the effect on the track formation is so as if the condensed ballast column is directly upon it. Now estimating that the tie is 26 cm wide and will be tamped on each side of a rail and a pressure of 8 tons for about 80 cm then a track formation pressure of:

$$s = \frac{16.000}{2/3.26/2.80} = 5'3 \text{ kg/cm } 2$$

is the result. The track formation pressure is very high and the track formation itself cannot stand it and it gives way and the condensed ballast column collapses. If the tamping lasts at all for some time, then it is only because of the speed of the rolling trains that these pressures have not an immediate effect. Besides that lesser axle pressures are more often than such which effect the above track formation pressure. A single hand tamping lasts therefore only for a short time. Therefore it is customary in track maintenance to have two tamping works done. The result according to picture no. 2 is then achieved, that means that the tie is setting on the condensed ballast-bed.



Picture No.2

not condensed

= condensed

The subsoil pressure will be therefore by a uniform condensing:

$$s = \frac{16.000}{2.26.80} = 3'85 \text{ kg/cm } 2$$

A hand tamping is never uniform, therefore a condensing according to picture no. 2 will never be achieved. The track formation pressure therefore will lie between 3.85 and 5.85 kg/cm, yet closer at 3.85, at a good two-fold hand tamping. On the average it can be estimated that it will be near 4'5. This relatively high track formation pressure has the effect that more and more ballast stones are pressed into the track formation until a condensing of the track formation is effected.

SPOT TAMPING WITH SMALL MACHINES

By using of vibrational or shock tampers the irregularity of the hand tamping is partly avoided. It is said partly because 4 working gangs are necessary for tamping a tie which cannot be uniform. The track formation pressure under the ties which are tamped by shock tampers will be between the ideal and the normal hand tamping, that is near 4'3 kg/cm 2. With vibration tampers a pressure of 4'7 kg/cm2 is achieved because of the lesser pressure and also irregular way of working.

THE SOUFFLAGE (MEASURED SHOVEL PACKING)

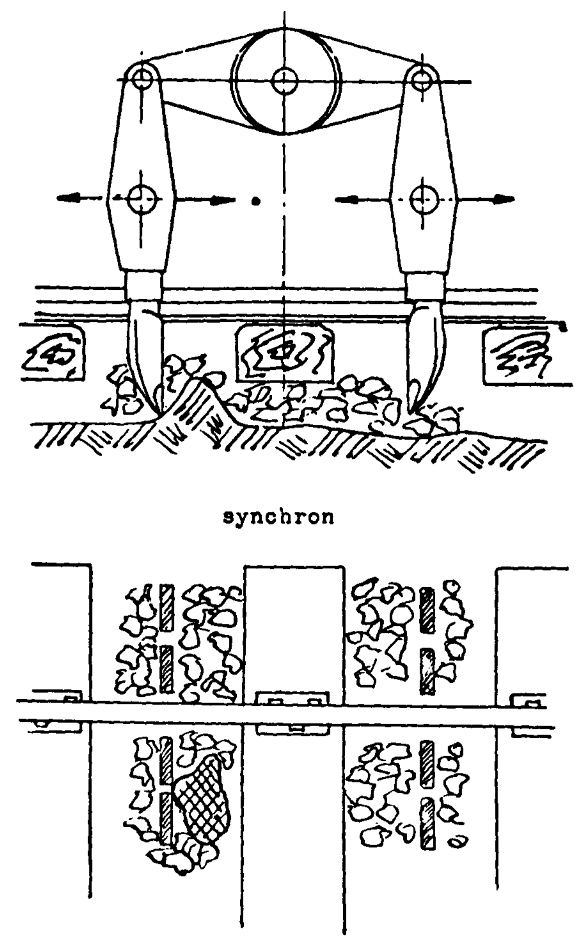
Usually the soufflage or a measured bringing in of small ballast into the track under the tie will be done in tracks which have been tamped before by hand or by means of small spot tampers, and where the track is already condensed by a continuous traffic. By bringing in just a small part of ballast, the condensing is improved or the ballast bed under this tie is more condensed and enlarged. Therefore it can be estimated that the track formation pressure under a tie after this work is less than under a tie tamped by hand ; it will be about 4'3 kg/cm2.

With lifts of more than 20 cm, at not condensed layer of small ballast would come into existence right underneath the tie with the effect of irregular settings of the track. The track formation pressure will not change but additional settings will be added.

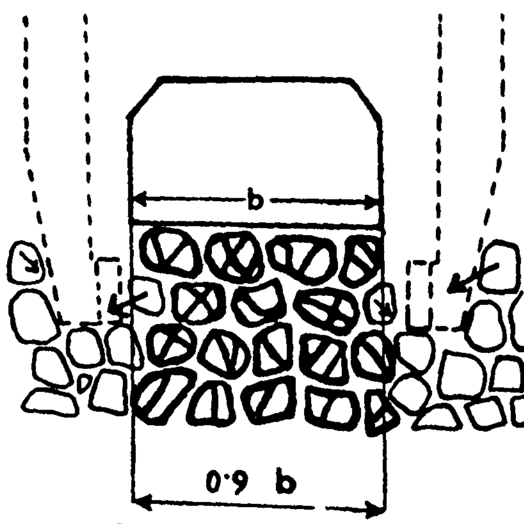
THE TAMPING BY SYNCHRON-CONTROLLED MACHINE

With on-track tampers with Synchron-controlled tamping tolls the ideal of uniform hand tamping could be achieved. But here with the Synchronous machine the tamping is dependent on the track which is not always the same for each tool, and therefore the ballast under each tie will not show the condensing which would be necessary to avoid stones falling back into the holes which were left by pulling out the tamping tools out of the ballast. This causes a smaller width of the tamped ballast column. In this case the dressure will be conducted over a smaller area to the track formation about according to picture no. 4. The pressure can be calculated according to this calculation

$$s = \frac{16.000}{0'9.26.2.80} = 4'3 \text{ kg/cm2}$$



Picture No. 3

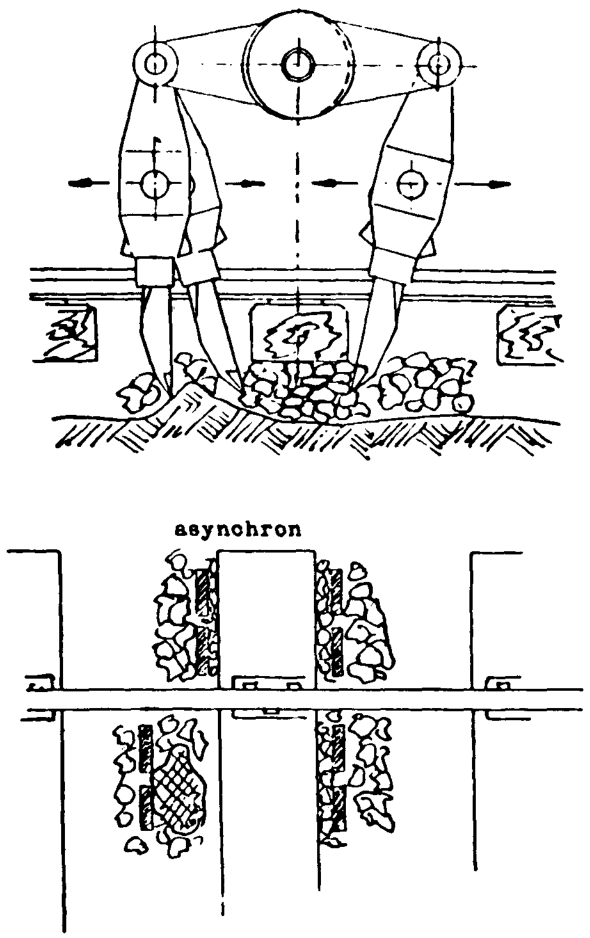


Picture No. 4 *Condensed*

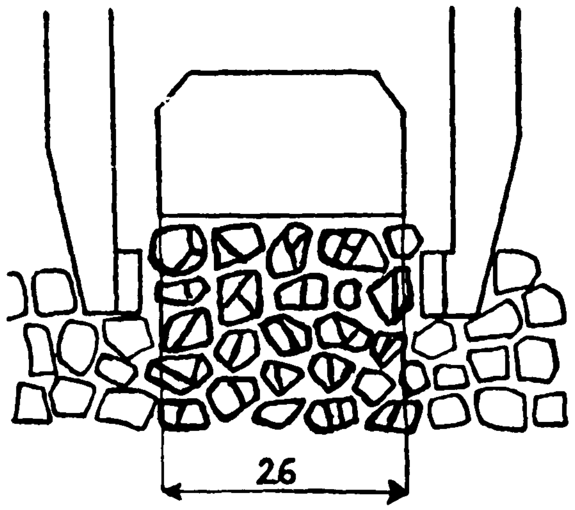
This shows that the tamping by Synchron-controlled machines is somewhat superior to the normal tamping by hand.

THE TAMPING BY NON-SYNCHRON CONTROLLED ON-TRACK TAMPERS

On-track tamping of the most modern manufacture finish their work of condensing only after the ballast under the tie is pressed by a predetermined pressure by each individual pair of tools under the tie. Therefore the uniformity of this tamping will be superior to the hand tamping and also to the tamping by spot tampers as well as to the soufflage and also superior to the tamping with Synchron-controlled on track tampers. A condensed ballast column as shown in picture no. 6 will be between tie and track formation according to the uniform condensing of the ballast. Any falling away of ballast stone will hardly occur any more. The track formation pressure of a such tamped tie will be equal to the ideal hand tamping mentioned at the beginning (track formation pressure 3'85 kg/cm2).



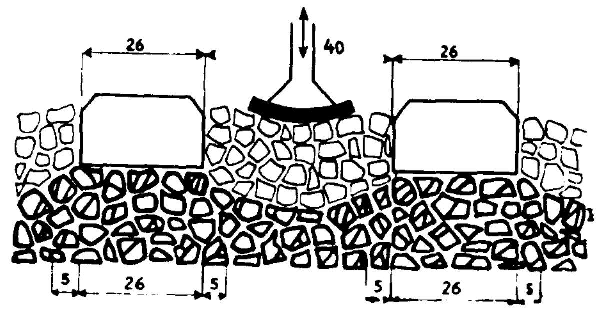
Picture No. 5



Picture No. 6
condensed

THE IMPROVED NON-SYNCHRON TAMPING BY ON-TRACK TAMPERS

The unfavourable influence of holes caused by lifting the tamping tool was always object of criticism in railway maintenance, and it was endeavoured to avoid these holes by a second tamping of the ballast between the ties. As the ballast between the sleepers cannot evade sideways it will be condensed by vibration vertical and also horizontal and is then in the position to distribute the pressure. If one succeeds to get a very strong horizontal condensing of the ballast between the sleepers then a pre-stressing like a vault as shown in picture no. 7 occurs.



Picture No. 7

In such a very stiff vault the subsoil pressure would be :

$$s = \frac{16.000}{66.2.80} = 1.5 \text{ kg/cm2}$$

In reality such a vault built from ballast stones will be elastical so that a pressure in form of continuous blows will not be conducted to the centre of the

wall. Considering an eighth of the distance between the ties as carrying on one side then the subsoil pressure will be like this :

$$s = \frac{16.000}{36.2.80} = 2,80 \text{ kg/cm2}$$

If only the ballast between the ties on side of the rails is condensed then the track formation pressure will be :

$$s = \frac{16.000}{36.80. + 26.80} = 3'25 \text{ kg/cm2}$$

After some time the effect of the vault will get lost so that on the average the subsoil pressure of :

$$s = \frac{3'25 + 3'85}{2} = 3'55 \text{ kg/cm2}$$

can be calculated.

THE EFFECT OF THE TAMPING

The effect of the tamping is depending on :

(a) The quality of the tamping, that is, the condensing of the ballast.

(b) On the settings of the track formation which work contrary to the condensing.

For this article, it was estimated that the quality of tamping for all kinds of tamping were equal, though this is not always true. The quality will be better with the new tampers with greater pressures than with old machines which have only small pressures at their disposal. Then it was supposed that always the same kind of soil is in the track formation. The figures given for the different track formation pressures already show that a certain plastic deformation is caused within the track formation (what really happens). To simplify the calculation let us assume that the plastic setting changes with the square of the track formation pressure, the following logical conclusion will be reached :

As the quality of tamping decreases with increasing settings it must be in indirect proportion to the square of track formation pressure.

A comparison of the aforesaid different ways of tamping results in the following table :

Way of Tamping	Subsoil pressure s in kg/cm2	Effect in comparison to the two-fold hand tamping
1. Hand tamping once	5'3	72
2. Hand tamping (two fold)	4'5	100
3. Tamping by vibration	4'7	90
4. Spot tamping	4'3	110
5, Soufflage	4'3	110
6. Machine tamping Synchron controlled	3'85—4'3	120
7. Machine tamping non-Synchron controlled	3'85	135
8. Improved non-Synchron controlled machine tamping (with condensing of ballast between the ties outside of the rails)	3'55	160

Picture 8

Picture 9

The above estimation shows that for instance (see 8.), the improved non-Synchron-controlled machine tamping will be better by 25% than the commonly used machine tamping. Better in this sense that the tamping will last longer. The condensing of the ballast between the sleepers has another great advantage, i.e. the resistance against a shifting of the track is increased and the danger of track rupture therefore decreases.

The improvement is obtained by this that 2 vibrators are mounted to the usual track tamping machine, these raisable and depressable vibrators in turn are fitted to a longer lever arm. Simultaneously with the tamping the following crib is condensed on the outside of the rails (picture 8 & 9) by these vibrators. The vibrators are movable suspended and make 2800 vibrations per minute driven by an electric engine. By the weight of the vibrators in connection with the vibrations the ballast within the crib is condensed and spanned.

CONCLUSION

The always present change of track conditions is mainly caused by setting of the track formation. These settings in turn are caused by high track formation pressures under the tie. A distribution of the pressure within the ballast bed can hardly be achieved because of the condensing of the ballast under the tie, and according to the pressure in form of condensing of the ballast under the tie, and pursuant to the pressure in form of continuous hits. The figures of the track formation pressure are estimated and finally a possibility is shown for improving the effect of the machine tamping. This improvement is achieved by a condensing of the ballast between the tie.

Millionth Brake Regulators for Swedish State Railways

It is gratifying indeed to note that Messrs. Svenska Aktiebolaget Bromsregulator, Malmo, Sweden recently delivered the millionth brake regulator to the Swedish State Railways and this brake regulator, we understand, is to be fitted to the private Saloon Carriage of His Majesty, the King of Sweden. The presentation of the Brake Regulator was performed at an impressive ceremony by Mr. Stig Tornebohm, Managing Director of Messrs. Svenska Aktiebolaget Bromsregulator and the regulator was received by Mr. Erik Upmark, General Manager of the Swedish State Railways.

It may be recalled here that when the company started only a few railways in Europe had fitted their freight wagons with continuous brakes; most freight trains were braked only by the locomotive and a variable number of handbraked wagons. One after the other the big railways in Europe have had to equip their freight vehicles with air-brakes or in some cases, with vacuum brakes. This firm has undertaken not only to be the suppliers of S. A. B. brake regulators and load-brake equipment but also to assist in design of the brake-rigging.

This firm has also developed the design and use of resilient wheels originally for tramways but latterly also for full-gauge railway vehicles, both driving and trailing. In motor-coaches they protect the motors and pinions from direct shocks and in many cases render special costly power-transmission gear superfluous.

It is a matter of great importance to Railroad Engineers in India to know that the Swedish State Railways were the first to use S. A. B. brake regulators and are still using them on the largest scale, 95 per cent of all S. A. B. brake regulators are installed on railway vehicles outside Sweden. S. A. B. Company has licence agreements for the manufacture of its products in Belgium, France, India, Japan, West Germany and Yugoslavia. Their Service Engineers are placed on a permanent basis in Belgium, Brazil, Germany, India, and Spain and there are subsidiary companies for service and sales in France, Great Britain and the U.S.A. In India M/s. S.A.B. Company of Malmo is represented by Messrs. J. Stone & Co. India Private Ltd., 16, Taratalla Road, Calcutta as its associates.

Welding Supplement

Electronics in Oxygen Cutting

By K. D. S. SEMPER*

IT is only eleven years since electronics appeared on oxygen cutting machines in Europe. Since that date great advances have been made in methods of control. The first machines were designed to operate from a black and white drawing, a spot of light approximately 1/16 in. dia. following the intersection of the black and white by means of a photo-cell looking at this spot and keeping it balanced half on the black and half on the white. Should the spot wander off the line by only a fraction of an inch the steering motor was caused to revolve by the unbalanced signal from the photo-cell thus causing the machine to follow most accurately the outline of the drawing. This system has proved most efficient and reliable, the only fault if any was the necessity of producing a drawing with a high black and white contrast and a line of at least 1/8 in. thick. (This is equal to a silhouette without filling in the centre). Obviously the next step was to make simpler templates, the simplest of all being a pencil drawing.

PREVENTING CONTACT WITH DRAWING

The latest machines work from these pencil line drawings, but in this case the drawing is floodlit and the photo-cell is caused to vibrate backwards and forwards across the line. The electronic control then compares the signal from each side of the line and turns the steering motor accordingly, so that the photo-cell follows the pencil line accurately. It is also essential to prevent damage to the drawings, as the driving wheel can scurf up the drawing as it crosses the line, especially on sharp corners. To prevent this, modern dual carriage machines are fitted with a driving roller on which the driving wheel runs, preventing any physical contact with the drawing and thereby making their life indefinite.

ELIMINATING DUST AND DIRT

Dust and dirt are of course, the major problem with electronic machines. If on the type of control where a spot of light is balanced half black and half white, the white becomes dirty, the machine will of course look for more white. On the type of machine where the photo-cell sees both sides of the line the machine still follows the line accurately although the signal from the photo-cell is reduced as the white has become grey.

It has been found from normal shop conditions that the dust problem has not been so bad as might be expected. It is possible to cover drawings with a thin film of special varnish to protect them or alternatively, sellotape covers the lines adequately. Drawings can also be made on various types of plastic sheet and these can be cleaned with a damp cloth. Placing small drawings under glass is advantageous but of course not so practical with large ones. Perspex is also suitable but is easily scratched and becomes translucent after a time.

TAPE CONTROL

Tape control of course, obviates all these points, but raises its own problems with regard to producing the tape. There are two main systems, the analogue and the digital, both have points in their favour. The digital system makes use of computer to prepare a magnetic tape which is placed in a console to control the machine. First of all it is necessary to prepare a punched paper tape giving certain dimensions from the drawings. This is then fed into the computer which works out and puts in the intermediate points to control the machine. The analogue system is similar to this except that no computer services are required, the console cabinet works out its own points on a parabolic interpolator and of course is a great saving in time and expense, with the added advantage that a punched tape can be read and alterations or corrections made immediately.

Between the 1 : 1 electronics and the computer there are the ratio cutting machines working direct from scaled drawings or photographic negatives and it is in this field that advances will be made during the next few years as this is the simplest form of templates for electronically controlled oxygen cutting machines.

* Sales Manager, Hancock & Co. (Engineers) Ltd., Croydon.

ARC WELDING SETS EXPORTED BY RUMANIA

By An Engineering Correspondent

Motor generator welding sets for connection to A.C. network Diesel driven generator welding sets. Transformers for hand welding.

WELDING technique has extended together with the general advance in industry as riveted constructions have been superseded by welded constructions and as welding has begun being used in large volume new work such as: steam boilers for thermo-electric power stations, equipment for the chemical industry, cement mills and kilns, high tonnage vessels, etc.

As a consequence, the manufacture of welding sets has greatly developed in countries and advanced industry. In Rumania, for instance, such sets are manufactured in large quantities, being successfully sold both in the home and in the international market. Here are some of the arc welding sets manufactured in Rumania today, and exported in large quantities (through the Industrialexport enterprise in Bucharest):

TYPE GES MOTOR-GENERATOR ARC WELDING SET AND TYPE TASM WELDING TRANSFORMER

Type GES arc welding sets made in Rumania consists of a squirrel cage motor for connection to a three-phase network of 220, 380 or 500 V and of a D. C. generator of a special design. The two machines are mounted in a well-ventilated common casing, fixed on 4 metal wheels. The star-delta starting switch of the driving motor and the graduated scale welding current control device are located on top of the casing. The generator's armature and the motor's rotor arc have a common shaft.

Simple and accurate control of the welding current, a good dynamic characteristic ensuring excellent stability of the arc throughout the range of the welding current, whatever the temperature of the winding of the control device, convenient commutation and perfect adaptation of the welding qualities to the requirements of the electric arc, are particularly important factors in achieving faultless welding.

Furthermore the design of the generator ensures quick voltage recovery—maximum 0.05 sec.—after the short circuit caused by welding and also lowers the voltage in no-load running.

The arc welding sets are supplied for intermittent welding currents up to 350 and 500 A at a 65 per cent running factor.

TECHNICAL DATA

	GES 350	*GES 500*
— Welding current at a 65 per cent running factor	350 A	500 A
— Welding current for continuous welding	280 A	400 A
— Total current range at rated voltage	80—400 A	100—700 A
— No-load voltage	80 V	90 V
— Generator voltage	30 V	35 V
— Motor's rated power	14 kW	28 kW
— Speed	1450 rpm	1450 rpm
— Dimension of electrodes	02—8 mm	03—10 mm

The wide current range of the set makes it suitable for the welding of light materials.

If no electric current is available, the GES 350 welding set is manufactured, driven by a 45 HP Diesel engine. The Diesel is directly coupled to the generator by the flexible coupling.

Welding making use of A. C. with transformers is recommended whenever there are simple operations to be performed and which may be effected with normal A. C. electrodes.

To that end, Rumania manufactures *type TASM 300 welding* transformers, designed for hand welding, using single-phase A. C. and a 300 A welding current with an adjustment range between 75 and 480 amp.

The transformer consists of a two column magnetic core made of laminations (on which the primary, main secondary and reactive secondary windings are mounted): a regulation device (consisting of a movable magnetic core actuated by means of a threaded axle and crank) the housing and a carriage provided with two wheels and two legs.

The service voltage in rated working conditions is of 32 V; the service voltage required by the arc depends on the intensity of the welding current. Thus, it varies from 23 to 39 V. The no-load service voltage is of maximum 74 V, respectively 63 V for the two adjustment ranges of the secondary circuit. The active rated power of 18.5 kVA for an efficiency of $\eta = 0.86$ and a power factor $\cos 0 = 0.56$.

The design of the TASM—300 transformers makes it highly efficient in high grade welding; it is moreover, easily handled and of low running costs.

The up-to-date technical feature of the afore-mentioned sets as well as their faultless construction have led to ever increasing orders coming in from abroad. Thus, Rumania exports a considerable number of arc welding sets to various countries, amongst which: Czechoslovakia, Turkey, India, the United Arab Republic, Iraq, etc.

At present, Rumania's industry is about to turn out new types of welding sets among which automatic welding ones, so that the export possibilities of the Industrial export company will shortly be widened in that sector, too.

Frogs and Crossing Procedure for Welding

By Dr. M. C. Bhatia
Welding Engineer, The Industrial Gases Limited, Calcutta

We have pleasure in publishing below a very interesting technical article on reconditioning of " Frogs and Crossings " made of high manganese steel, contributed by an eminent Welding Engineer Dr. M. C. Bhatia of The Industrial Gases Ltd., Calcutta. Messrs. Industrial Gases of Calcutta are pioneers in the manufacture of welding equipments and accessories.

The author has taken considerable pains to prepare the technical paper on the subject under reference and we take this opportunity of inviting the attention of the Engineers on Indian Government Railways and request them to explore the possibilities of implementing some of the constructive suggestions of Dr. Bhatia.—Editor

IT is much cheaper to repair and recondition or in other words reclaim—the FROGS AND CROSSINGS made of high Manganese Steel—than to replace the same. Indian Railways are already doing this work and giving more and more serious thought to reclamation of worn out FROGS AND CROSSING by the best possible means & in the cheapest possible manner. It is in view of this fact that this note may be of some use to those concerned.

FROGS AND CROSSINGS for points on the Railways that have to stand especially heavy and fast trains, or a considerable daily average number of trains—are manufactured of high manganese steel. The reason for this, of course, is that such steel is much durable and shock resistant than ordinary high carbon steel.

High manganese castings are rather costly and the fact that they can be reclaimed at a cost of 25% to 35% of the original by Arc welding with special Electrodes, is important from a stand point of economy.

FROGS AND CROSSINGS can be reclaimed either on the shop floor or on the open track. In the shop the ordinary electric welding generator is used. For open track work, a petrol driven welding generator set and a portable grinder, both mounted on a truck are required. The only difference in the two operations is that the welding proceeds a little more slowly of the open track unless water for cooling the casting is available.

Proper preparation is essential for welding high manganese steel by the process of Arc welding. All soft spots should be ground out of FROGS AND CROSSINGS. Any fine cracks on the surface to be built up should be removed. Such cracks will inevitably appear in the weld deposit unless removed. All rust oil & grease should be removed before welding commences, or the deposited metal will be porous. A scratch brush with a suitable acid solution should serve the purpose. Murriatic acid solution cut with zinc will serve the purpose.

It is always better and cheaper to repair FROGS AND CROSSINGS BEFORE the wear becomes too great. When several layers of weld Metal have to be put on, it is more expensive and more difficult for the operator to do a good clean job.

After the casting has been prepared for welding as outlined above, work may commence. The welder should have at hand a light hammer, a straight edge, and a hose with about a pencil stream of cool water flowing. The ends of the FROGS AND CROSSOVER should be lightly dammed up with sand, so that about half an inch of water is always in the trough. The purpose of this is to keep the casting cool, and should not be used for quenching.

Special Manganese Electrodes—3/16"—should be used unless only one layer is to be put, in which case 1/4" rods may be used. With the 3/16" electrodes-130 to 170 amperes are used. With $\frac{1}{4}$"-175 to 225 but the lowest amperage that will allow of steady are flow and good penetration is best. The cooler that the member being welded is kept the fewer the contraction stresses that are set up.

The bead should be laid with a half moon weaving motion with the two ends of the half moon pointing in the direction towards which the operator is working, viz;

The bead should be about ¾" wide about 3" at a time should be welded. The operator should then immediately take a light hammer and peen the bead thoroughly. The practice of water quenching the bead should not be used since the special manganese electrodes are of such composition that the resultant bead is air toughening.

If the casting has more than one section being built up, as it usually has, it is best for the welder to deposit the next bead on a new section, rather than to keep on at the place where he starts. This allows further time to cool. Each section should be worked on in order before returning to the original bead.

One head having been laid on each section, a second bead should be deposited alongside the first one, rather than to be a continuation of it. The same procedure follows at each of the sections. When more than one layer is required, the entire first layer should be deposited before starting the second.

After the first layer is finished and if more layers are necessary, the former should be thoroughly scaled and cleaned before proceeding. This is exceedingly important as if any scale or dirt remains, it will cause boiling and porosity in the upper layers.

The operator should frequently use the straight edge, so as not to deposit any excess weld metal as all such excess must be ground off.

If these instructions are carefully followed, the reclaimed FROGS OR CROSSING is just as good as new.

Further technical advice, and information on recommended types of special purposes manganese electrodes, etc. can be given if required.

Long Welded Rail Laying on British Railways

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 1C0, 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.

QUENCHWELD

By Eutectic Technical Service

Larsen & Toubro Ltd., Madras-2

THE Eutectic Welding Alloys Corporation, pioneers in the manufacture of low temperature Welding Alloys have perfected one more step in the welding of cast iron.

The 'Quenchweld' process is the latest 3-step method for producing safe, long-lasting weld repairs on cast iron, with speed economy and dependability. It requires no special equipment beyond an AC or DC welding machine.

The three steps are:

Step A: Vee out cracks and cut stress-relieving grooves with 'Quenchweld' electrode 'A'.

Step B: Seal in contaminants like sulphur etc. with 'Quenchweld' electrode 'B'.

Step C: Join and fill with Quenchweld Electrode 'C'.

THE PROCESS

Step A:

'Quenchweld' Electrode 'A' is a metal removing electrode, whose special coating concentrates the arc at the point of application for maximum blasting effect. Its purpose is to vee out cracks or joint areas, providing greater bonding surface for filler alloy. A remarkable feature of this electrode is its ability to accomplish the grooving without overheating the cast iron.

Step B:

'Quenchweld' Electrode 'B' is a "buttering" electrode formultated to seal off contaminants in the weld area and to prepare a surface metallurgically suited to the final joining operation. It is well-known that the presence of sulphur elements in the base metal tends to embrittle and crack the weld. 'Quenchweld' Electrode 'B' effectively seals off such elements.

Step C:

'Quenchweld' Electrode 'C' is an alloy containing special formulations which permit accelerated cooling. The welds obtained with 'Quenchweld' Electrode 'C' are dense, crackfree and strong. This electrode permits quenching with wet cloth or air blast immediately after each pass. Thus quenching after each pass will check the heat on the base metal permitting continuous welding without having to wait to allow the casting to cool down before making the next pass.

The resultant welds are absolutely free of blowholes, porosities and cracks, and are fully machineable.

The physical properties of a weld made with 'Quenchweld' Electrode 'C' compare well with those of cast iron.

Recently the Central Railway Loco Workshop, Bombay, carried out initial test on a few critically cracked cast iron Housings which were patched with mild steel and welded successfully with the Eutectic Quenchweld process. A recommendation made by the Works Manager and C. M. E. has led the Railway Research Centre at Chittaranjan to process the Quenchweld technique for general railway approval and standardisation. The test is going on at present.

Designed by Eutectic Welding Alloys Corp., Flushing, N. Y., it is hoped that this new 3-step method will be a boon to all industries in solving cast iron welding problems.

Welding News

CAST-IRON WELDING

The Fontargen E 116 electrode, one of a range of low-heat, metal-joining products, has been designed for difficult welds on grey and alloy cast-iron, for welding these metals to steel, and for surfacing and re-building cast-iron where maximum bond-strength and freedom from cracking are required. The electrode has a core of nickel-iron alloy and the coating has been developed to give good flow and bonding properties even at low amperages.

Recently, design changes required a 1½-ton cast-iron bedplate to be reinforced. This was successfully carried out by welding-in a 1½-in. steel plate cold, using this electrode. No pre-heating of the casting was required.

To obtain the required rigidity, 180 plug groove-and-fillet welds were made. Welding was completed in 6 hr., using an 8-S.W.G. electrode at 140 A. and 28 lb. of electrode was consumed. The total cost was considerably less than that of a new casting.

Further details can be obtained from the manufacturer, Welding Improvements Limited, Lady's Lane, Northampton.

METERING REGULATOR FOR GASES

The Harris Model 92 (multi-stage) regulator, the first of its type to be manufactured in the United Kingdom, measures the flow of industrial gases in cubic feet per hour. Cheaper and more robust than the comparable regulator-flowmeter combination, it also possesses the advantage that its accuracy is not affected by the angle at which it is fitted to the cylinder. Unlike ordinary pressure regulators it has a restricted outlet with an accurately-machined bore. By governing the pressure in the outer chamber of the regulator, a measurable amount of gas flows out of the restricted outlet.

Flow remains constant, regardless of changes in cylinder pressure, so that all the gas is used. Neoprene valve seats and diaphragms in the second stage have been incorporated as a safety factor.

Further details can be obtained from the manufacturer, British Industrial Gases Limited, 700 Great Cambridge Road, Enfield, Middlesex.

SILVER BRAZING ALLOYS

Five Fontargen silver brazing alloys have been developed for specific needs. A.300 is a brazing alloy containing about 4 per cent silver, it has a bonding temperature of about 750 deg. C., and a working temperature of about 870 deg. C. A. 307 is a silver brazing alloy with a bonding temperature of about 570 deg. C., and a working temperature of 630 deg. C. A.310 is a silver brazing alloy with a bonding temperature of 560 deg. C. and a working temperature of about 620 deg. C. It is a quasi-eutectic alloy for use where a very small melting range is required. A.311 is a sliver brazing alloy with a bonding temperature of 650 deg. C. and a working temperature of about 710 deg. C. It is cadmium free and is valuable for food and drink preparation for this reason. A.312 is a silver brazing alloy with a high silver content and additions of nickel and manganese. It is in foil form containing a thin central lamination of copper giving the joint remarkable elasticity. It is produced for brazing hard metal inserts to give high bond strengths. All these alloys have tensile strengths of 22 to 25 tons per sq. in. Further details can be obtained from the distributors for the U.K. and Eire, Welding Improvements Limited, Lady's Lane, Northampton.

WELDING RECTIFIER

The CVR200 constant-voltage selenium-plate direct-current rectifier has been introduced for CO_2 welding. It is a 3-phase natural-air-cooled constant-voltage transformer rectifier providing a voltage range of 14 to 30 volts d.c. and a continuous output of 200 amp. d.c. at 25 V. (5 kW.) with an input of 415 V. Fine voltage selection is provided in 16 steps, ensuring accurate voltage control to meet any arc characteristic.

Two selector switches give the required voltage: one for coarse, and one for fine, selection, allowing steps of approximately 1 V.

A feature of the CVR200 is the special variable stabiliser which gives a smooth arc characteristic and provides any added inductance required to minimise spatter loss.

The rectifier is of all-welded construction, is mounted on 5-in. hard-rubber wheel castors and has all panels except the front removable without disturbing the wiring. A special version is available which combines the CVR 200 with a Sprite CO_2 welding unit mounted on a turntable on top of the CVR200. This unit provides a CO_2 welding unit which is completely mobile and fully flexible in operation for high-speed production welding. Further details can be obtained from the Sales Department, Lincoln Electric Co. Ltd., Welwyn Garden City, Hertfordshire.

(Courtesy: "The Railway Gazette")

Edited & published by Sri S.M. Sivaprakasam for "The Indian Railways Workshop Magazine", Post Box No. 21, Tanjore and Printed by T. S. Gopal Row at M. K. Press, Tanjore.