

The Indian Railways Workshop Magazine

vol-7

no-4

August-1961

SL
DSIS3m2, NS3
N 61.7-4
161453

The Indian Railways Workshop Magazine

International, Steam, Electric and Diesel Railway Traction Number

335

Vol.VII No.4

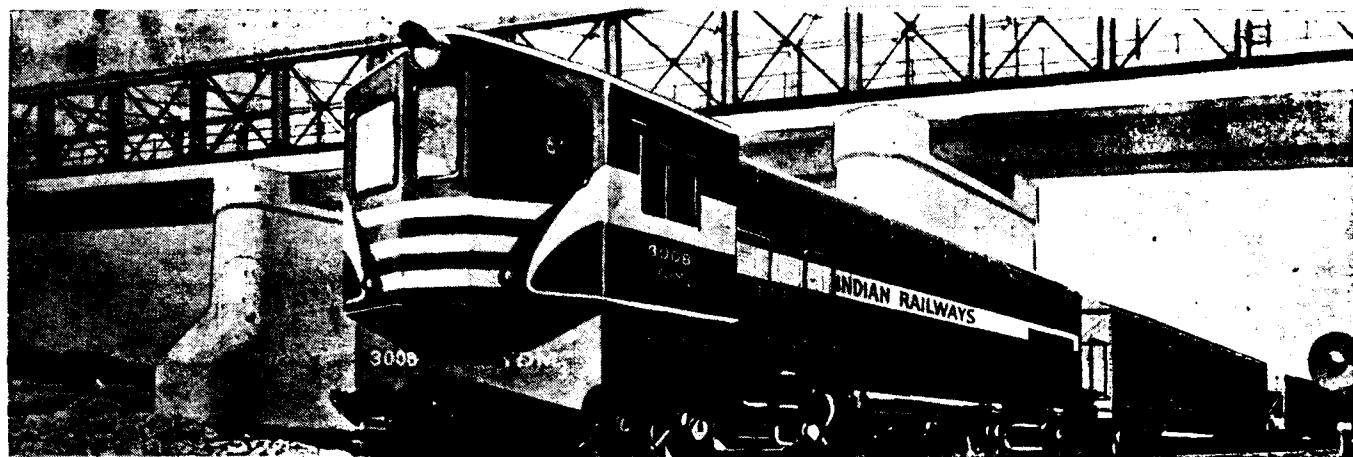
August 1961

Verified

Price 50 nP.

CONTENTS

	PAGE
What the Railways expect from the Public	1
Export success of Mechanical-Transmission Locomotives	5
Beyer Peacock (Hymek) Ltd. hand over to British Railways (Western Region) the first of 95 type 3 diesel-Hydraulic Locomotives	6
Electric Industrial Locomotives from the German Democratic Republic	8
Refuelling of Diesel Locomotives	11
Torque Converters can be different	14
Modernity in Crankshaft Manufacture	32
The Relative Merits of Diesel and Electric Traction and the problems of change over—A Phase of the Railway Traction Development	36
Axle-Suspended Traction Motor for D.C. and Rectified A.C.	46
Silicone Treatment of Overhead-Line Insulators	48



Indian Railways purchase 70

GENERAL MOTORS LOCOMOTIVES



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

40 Model GT16, 2600/2400 H.P., broad-gauge locomotives have been ordered for the Northern Railway. Largest, most powerful General Motors locomotives ever offered overseas, these units will be based at Moghal Sarai and will be used in time freight operations hauling heavy goods trains.

30 Model GA12 meter-gauge locomotives will be delivered to the Northeast Frontier Railway and will be maintained at Siliguri. These 1240/1150 H.P. locomotives, rated to insure 1150 H.P. under site conditions for tractive purpose, will also be used to handle increasing goods traffic. Equipped with 1-B-B-1 wheel arrangement, they have a 12-ton axle load and will provide excellent riding characteristics as well as reduced rail stresses with less rail and flange wear.

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

GENERAL MOTORS OVERSEAS OPERATIONS

Division of General Motors Corporation, New York 19, N. Y., U. S. A. Cable Address: Autoexport
Locomotive plants in the U.S.A. and Canada.
Associate builders in Australia, Belgium, Germany, South Africa, Spain and Sweden
General Motors Subsidiaries, Branches or Representation throughout the world.
World's Highest Standard—270 to 2600 H.P.



What the Railways Expect from the Public

If the public has certain rights as tax-payers and passengers from the railways, it must be conceded that the railways have certain expectations from the public and these we will now outline and explain.

The first and most important thing that the Railways expect from the public is the correct payment of the fares for their journeys. After all the life blood of the Railways are their earnings and these are obtained from passenger fares and goods charges. By not paying this correct dues under both these heads the Railways lose a considerable amount of revenue which if pooled together for all the railways would amount to many lakhs and even some crores of rupees.

Because of the rush of traffic especially in the suburban trains a very large number of people travel without purchasing tickets, depending upon their cunningness in evading the ticket collector at stations and the travelling ticket collectors on the trains themselves. Further a large number of railway travellers, especially in suburban trains buy a lower class ticket and travel in a higher class, hoping to hookwink the travelling ticket collectors.

Further people coming to the stations to meet their relatives and friends or to see them off are expected to buy platform tickets but very few of them do so, expecting in the rush to evade the ticket collector who cannot possibly check all tickets.

Similarly in booking their luggage or their goods passengers and merchants by means of bribery and corruption get their weights shown less to what they are, hoping therefore to evade the travelling ticket inspector or goods inspector. Through these anti-social methods of the public the Railways lose a tremendous amount of money. It is because the Railways are a Government concern and monopolistic at that that they can bear this heavy loss, which would have driven a private firm to bankruptcy in less than a year.

In purchasing tickets and booking goods the public is expected to queue up at the right counters and not crowd round it, to the detriment of all. Further the booking clerk of the Railways expect an amount to be paid within reasonable reach of the fare. The booking clerks carry a reasonable amount of change but if thoughtless people tender a hundred note each time they want to purchase a five rupee ticket that change would be denuded very quickly to the detriment of those people who follow.

Railways, to safeguard their interests, employ travelling ticket collectors who after examining the tickets desire to inspect and weigh your luggage in case they suspect it to be shown underweight. While it is admitted that for one that is caught with excessive

weighed luggage fifty escape detection, they should not complain that they are charged high extra charges.

The travelling habits of our Indian people are most reprehensible. They at all times carry excessive luggage and worst of it is that they want to take it all with them in the compartment. What with heavy boxes and trunks and huge big beddings and numerous pots and pans the compartment soon gets scuttled, and there is hardly any room to move. The Railways expect the public to book their heavy luggage and entrust it to the custody of the guard. Very few people even in upper classes ever do this with the result that travelling in railway compartments sometimes becomes an absolute nightmare of discomfort.

While travelling, the Railways and their servants expect common courtesy but the words "please" and "thank you" seem to be absent in the dictionary of railway travellers. While they expect and complain bitterly of the want of courtesy of railway servants they themselves are most intolerant and aggressive in their attitude to railway servants.

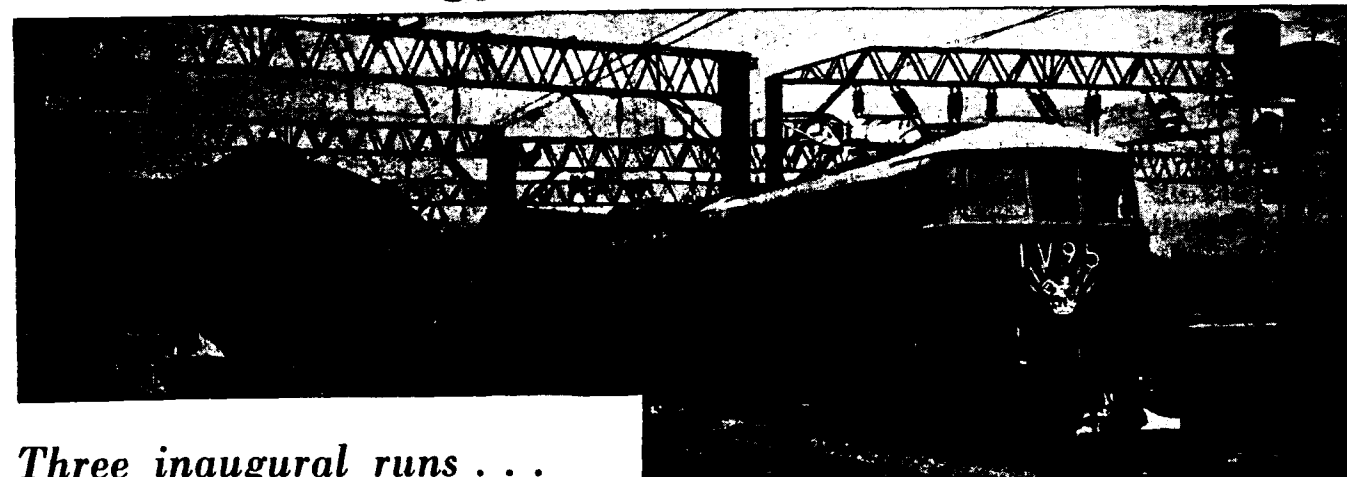
Cleanliness in Railway compartments is a serious draw-back with our Indian public. It is very seldom that compartments and especially the lavatories are kept clean and hygienic. Knowing that a number of people have to use the same latrine on a journey a little consideration for others should induce a person in flushing a lavatory after use, but this is very seldom done, with the result that most lavatories stink, after even a short journey. Further the eating habits of our people are obnoxious. They usually bring their own foods for the journey tied up in paper or cloth bundles or even in containers but after they have eaten they through the left-overs on the floor of the compartment instead of out of it. The result is that usually our railway compartments, be they upper or lower class are infested with vermin of all sorts, many kinds of ants, bugs etc. Although the railways have often to resort to fumigation of a compartment if it is badly infested, they hardly succeed in complete elimination, because these verminous creatures breed very rapidly and reinfest the compartment in a short time. The shocking and disgusting habit of eating the betel leaf and spitting all over the compartment both inside and outside and leaving unsightly marks which are difficult to eradicate is another habit which the Railways expect the travelling public to refrain from.

Apart from the compartments of railway carriages, most of the waiting rooms at stations are left in an unsanitary condition by our travelling public whereas with a little thought and consideration for others they could be kept clean. The furniture is often broken and the chairs in particular have their cane seats ripped off due to misuse.

Talking of destruction the upper class compartments in Suburban trains are often left in a disgraceful condition. The rexine covers of seats are cut and ripped so as to make them unsuitable for sitting. This is often the result of vandalism and sabotage. Some dismissed railway servants to pay a grudge against the railway and he does it when nobody is looking by wanton destruction. Pilfering is nowadays a very common habit and things like bulbs, switches, brass items like water cocks, taps are stolen wholesale from railway compartments. In many cases the safety bolts and clips which are

NBL Locomotives

OF THE NEW ERA



Three inaugural runs . . .

1. A North British built Electric Locomotive hauls the first train on the newly electrified Manchester-Crewe route.

Main Contractor :- The General Electric Company Limited of England.

2. A North British Diesel-Hydraulic Locomotive leaving Paddington with "The Cornish Riviera" to inaugurate the diesel service.

Powered by NBL/MAN Diesel Engines and Voith/NBL Transmissions.

3. The first Pullman Diesel Train Set on British Railways. All these train sets are powered by NBL/MAN Diesel Engines.

Main Contractor :
Metropolitan Cammell Carriage & Wagon Co., Ltd., with electrics by The General Electric Co. Limited.

We also produce a range of
Shunting Locomotives from 200 to 900 H.P.

**NORTH BRITISH
LOCOMOTIVE CO. LTD., GLASGOW**

London Office : LOCOMOTIVE HOUSE, BUCKINGHAM GATE, S.W.1.

Photographs by Courtesy of British Railways

Representatives in India :
JAMES FINLAY & CO. LTD.,
CALCUTTA, BOMBAY, NEW DELHI, VIZAGAPATAN

meant for the safety of passengers particularly at night are deliberately damaged or removed with the result that doors or windows cannot be closed and safety becomes non-existent.

While on the subject of safety it has now become a common habit to hang on the outside of railway compartments of Suburban trains and in spite of the fact that there are so many accidents non-fatal and fatal, the habit persists. Another habit which makes for the lack of safety is the public crossing railway lines at stations. They do not use the correct entry or exit gates but prefer to dodge the ticket collector by going to the opposite end of the platform and leaving the station by crossing the railway lines.

Dining cars and refreshment rooms at Railway stations are provided by the Railways as an amenity to the public and nowadays the meals are even subsidized. However the public generally are reluctant to make use of this amenity with the result that dining cars and refreshment rooms run at a heavy loss and as a consequence the food preparation deteriorates and sets up a vicious circle in the catering department of the Railways.

The Railways as a rule get a considerable amount of work done on contract. In the Civil Engineering Department, earth works, excavation and filling, structural work, building construction etc. is done on contract. Normally tenders are invited and the contract awarded to the lowest tenderer. Very seldom are there contracts carried out to specifications laid down, and by resorting to bribery and corruption, inferior quality of work is accepted. This also applies to the Mechanical Department where the Railways buy a very large amount of raw material and finished material. Purchases are supposed to be made to specifications and drawings supplied by the Railways to contractors. More often than not inferior quality of material is supplied and accepted by the Railways for some financial consideration. This does not of course mean that all railway staff is corrupt and it would be wrong to tar them all with the same brush but it is the few who stoop to corrupt practices who ruin the name of the Railways. While the contractors often complain that they have to bribe and corrupt in order to get the work done—their goods accepted, they must share for the introduction of these corrupt and anti-social practices.

On many railways it has become a habit to pull the alarm chain and thereby bring a train to a standstill. On enquiry in the compartment where the chain is pulled no one will point out the culprit and so while he gets away from the penalty to be imposed the train is unnecessarily delayed. On suburban trains, frequent pulling of the chain is resorted to for trivial reasons, and the work of punctual running of trains is impeded.

The Railway provides free amenities like sweepers at certain stations to clean out the compartments and latrines and also cold drinking water during the hot weather but the travelling public makes scant use of these facilities.

Beggars on trains are a frequent nuisance to everybody and notices are displayed to discourage beggars and hawkers in trains and complain about them. However very few people complain and do not even co-operate with the Railway staff in getting rid of them.

Metaphorically any stick is supposed to be good enough to beat the railways but the railways could with equal right and justice quote to the public at large the biblical saying "let those of you who are not guilty of any of the faults indicated above cast the first stone."

Export Success of Mechanical-Transmission Locomotives

By An Engineering Correspondent

THREE 0—6—0 diesel-mechanical locomotives have recently been delivered by The Drewry Car Co., Ltd., City Wall House, Finsbury Pavement, London, E. C. 2, for service on the metre-gauge system of the West of India Portuguese Railway. They are used for marshalling rakes of iron ore wagons in and around the Port of Mormugao, and for trip working to and from the mines with empty and laden wagons over a distance of 45 kilometres.

COMPREHENSIVE SERVICE

Equipped for working vacuum-fitted stock, the new Drewry locomotives have a Westinghouse exhaustor driven from the engine. A vacuum-operated "straight" air brake is provided on the locomotive, with "straight" air brake only when working non-fitted wagons. Together with the wide speed range offered by the five-ratio transmission, these features enable the locomotives to be employed on passenger working, thus adding greatly to their all-round usefulness to the W. I. P. Railway.

In design these versatile machines may be said to follow well-proven Drewry principles for narrow-gauge units, as supplied to many overseas territories. The mechanical parts were built by Robert Stephenson and Hawthorns, Ltd. Weight is 29.6 tons in working order, approximately equally distributed, to comply with the maximum permissible axle loading of 10 tons.

Being of metre gauge, outside plate frames and fly-cranks are employed, which is the maker's usual practice for locomotives for 3-ft. 6-in. gauge track, and under. Leading particulars are set out in an accompanying table.

DREWRY 0—6—0 FOR W. I. P. R.

Leading particulars

Rail gauge	1 metre
Length over frame	22 ft. 4½ in.

Length over buffers	27 ft. 0½ in.
Maximum height	11 ft. 0½ in.
Maximum width	8 ft. 6 in.
Wheelbase	9 ft. 0 in.
Wheel diameter	3 ft. 3 in.
Fuel tank capacity	225 gallons

Diesel prime mover in the W. I. P. R. Drewry locomotives is the Gardner 8L3, normally developing 204 b.h.p. at 1,200 r.p.m., but derated to provide 194 b.h.p. under site conditions.

The Gardner L3 series automotive-type engine is built with four, five, six and eight cylinders, all having a bore of 5.5 in. and a stroke of 7.75 in. It is a direct-injection four-stroke engine having one inlet and one exhaust valve per cylinder, located one on each side of the central fuel injector. Cylinder heads are in units and the 8L3 has four two-liner blocks.

Cylinder blocks are cast in special ductile high-tensile cast iron carrying detachable "wet" liners, into which are pressed renewable "dry" type sleeves. The blocks are bolted to the crankcase by large high-tensile through bolts, which extend through the upper half of the crankcase and at their lower ends are screwed into the lower half crankcase.

Separate construction of cylinders and "wet" liners permits the replacement of worn cylinder liners in a few hours, without the need to stock and transport heavy cylinder blocks. Liners may be re-sleeved and carried in stock for immediate use on any engine.

Fuel injection is by a Gardner-C. A. V. type BPF fuel pump in which the C. A. V. pumping parts are operated by means of Gardner cams and tappets. Sprayers are Gardner multi-hole type. Engine starting is by means of two C. A. V. 24-V. axial-type electric starter motors. No heater plugs or other external devices are required for starting from cold, good starting characteristics being inherent in the open chamber combustion system.

(Continued on page 6)

BEYER PEACOCK (HYMEK) LTD. HAND OVER TO BRITISH RAILWAYS (WESTERN REGION) THE FIRST OF 95 TYPE 3 DIESEL-HYDRAULIC LOCOMOTIVES

THE first of 95 1,700 h. p. Type 3 Diesel-Hydraulic locomotives to be built by Beyer Peacock (Hymek) Ltd. for the Western Region of British Railways was handed over on Tuesday, 16 May, by the builders' Chairman, Mr. H. Wilmot, C. B. E., at a ceremony in Paddington Station. Amongst those present were Mr. K. W. C. Grand, Member, British Transport Commission; Mr. R. F. Hanks, Chairman, Western Area Board; Mr. J. R. Hammond, General Manager, Western Region of British Railways, and Mr. R. A. Smeddle, Chief Mechanical and Electrical Engineer, Western Region.

The total of 95 locomotives was ordered by the British Transport Commission for further stages of the Western Region's schemes for the complete replacement of steam by diesel power in the Bristol area, the West of England (West of Newton Abbot), and in South Wales, including all the principal passenger, parcels and freight services, and many other trains between these areas and London (Paddington). About 1,100 steam engines are being replaced by some 500 main-line diesel locomotives under these schemes. Deliveries of the 95 main-line locomotives will be completed in 1963.

(Continued from page 5)

The transmission comprises a Fluidrive Vulcan-Sinclair coupling in conjunction with a Wilson-Drewry five-speed direct air-operated epicyclic gearbox, and a jackshaft-mounted spiral bevel reverse and reduction unit.

There are several advantages in using a fluid coupling; not least of these is to prevent the passing of torsional oscillations and severe shock loads. Stemming from this, a longer life can be expected from all the individual assemblies making up the transmission, through the reduced rate of wear and tear.

The Fluidrive unit gives a smooth take-up of the drive simply by accelerating the engine. Torque out-

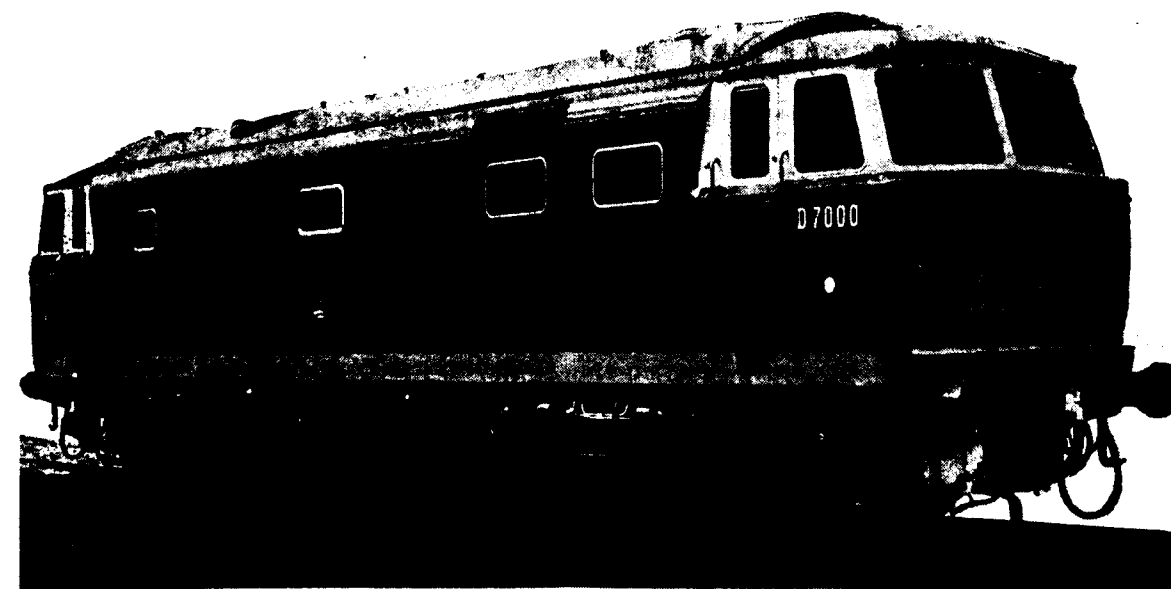
Beyer Peacock (Hymek) Ltd., — in which Bristol Siddeley Engines Ltd., and J. Stone & Co. (Deptford) Ltd., are partners with Beyer Peacock & Co., Ltd., — received an order from the British Transport Commission for the supply of 45 diesel-hydraulic main line locomotives. These locomotives were scheduled to commence delivery at the end of July, 1961. This order was subsequently increased to 95 and it is the first of these Type 3 locomotives that has now been handed over to the Western Region of British Railways. This is a completely new design of diesel-hydraulic locomotive powered by one Bristol Siddeley Maybach MD. 870 engine and one K. 184U Stone-Maybach Mekydro hydraulic transmission. The rated horse-power is 1700 and the locomotives are designed for general purpose work on the main line with a maximum speed of 90 m. p. h.

The 95 locomotives are being designed and constructed at the works of Beyer Peacock, Gorton, to the general requirements of the British Transport Commission under the overall direction of Mr. J. F. Harrison, Chief Mechanical Engineer, British Railways Central Staff, Mr. R. A. Smeddle, Chief Mechanical and Electrical Engineer, Western Region, being

put is practically equal to the torque input, even at 100% slip, that is when the output shaft is stationary. Thus maximum torque can be produced when starting the load from rest.

Special features on these locomotives include the fitting of Timken roller-bearing axleboxes with manganese steel faces. The fully enclosed cab is insulated for tropical conditions; controls are duplicated on each side of the cab and a driver's swivelling seat is provided in both control positions.

There are shunters' platforms at each end of the locomotive, A.B.C. central combined couplers, and an electrically operated warning bell.



responsible for collaboration and inspection with the builders. The diesel engines are supplied by Bristol Siddeley Engines Ltd., and hydraulic transmissions and final drives by J. Stone & Co., Deptford.

Considerable attention in the design of the locomotive has been given to accessibility of parts making for easy maintenance in service. Simplicity and clean lines have been attained by keeping the locomotive as free as possible of extraneous detail. The locomotives are finished in blending shades of green and the whole effect is one of a pleasant appearance of stability and power, to which the British Transport Commission's Design Panel, and their nominated consultant, paid particular attention.

Railways overseas will undoubtedly be interested in the design and performance of these new diesel-hydraulic locomotives and a most useful export "shop

window" will be provided by their appearance on the Western Region of British Railways.

For 107 years Beyer Peacock have been building locomotives at their Gorton works and their output has included many different types of locomotives for railways in every part of the world. They are particularly well known for the Beyer-Garratt articulated locomotive, which is still the backbone of the motive power of many railways overseas where conditions are severe and with restrictions of gauge and axleload. In the last few years there has been a drastic change in the requirements of railways with regard to their motive power, and diesel and electric locomotives have now largely displaced steam in new orders. Whilst Beyer Peacock are still able to produce steam locomotives, they have, in more recent years, increased their manufacture of electric and diesel locomotives and they are participating in the supply of modern types of diesel locomotive for British Railways' modernisation programme.

CODE FOR DESIGNATION OF STEEL

With a view to simplifying reference, marking and identification of the various types of steel, the Indian Standards Institution has just published IS : 1762-1961 Code for Designation of Steel. The standard specifies the symbols to be used for the designation of steel on the basis of its mechanical property, chemical composition, physical condition, etc. For the sake of brevity,

it is intended that only the minimum number of symbols should be used.

The system of codification has been evolved on the principle that designations, instead of being arbitrary, should bear some relationship to important characteristics, such as tensile strength, chemical composition, physical and surface conditions, etc.

Electric Industrial Locomotives from the German Democratic Republic

THE nationally owned factory Lokomotivbau-Elektrotechnische Werke "Hans Beimler" at Hennigsdorf near Berlin is the only factory in the German Democratic Republic manufacturing electric locomotives and equipment for electric rail motorcars. The locomotive manufacturing program reaches from the smallest mine locomotive over heavy and heaviest locomotives for open-cut mines to most up-to-date locomotives for standard gauge lines operating on direct current or single-phase alternating current. In addition, electrical equipment for rail coaches and rail motorcars, tramways, and trolley buses is made in that factory. Moreover, the factory is also engaged in the development of control units for Diesel hydraulic rail motorcars so that it is able to meet nearly all requirements of industry and transport.

This factory devotes an essential part of its total production to the manufacture of locomotives for open-cut mining.

The following is a summary of the various types of locomotives and rail motorcars as well as of their capacity and application.

In principle three different types can be distinguished in respect to these locomotives:

1. 70-ton to 75-ton locomotives 900 mm (35 11/16") or 1000 mm (39 3/8") gauge for voltages of 600 and 1200 volts;
2. 100-ton locomotives 1435 mm (4' 8 1/2") and 1524 mm (5') gauge for voltages of 1200, 1500 and 2400 volts;
3. 150-ton to 170-ton locomotives 1435 mm (4' 8 1/2") and 1524 mm (5') gauge for voltages of 1200 and 1500 volts.

The 75-ton locomotive 900 mm (35 11/16") gauge for 1200 volts has been supplied in large lots to the German mining industry. It has stood the test very well in severe overburden operation since nearly ten years. This type is a bogie locomotive Bo' Bo' and is preferably employed in older open-cuts on account of its narrow and extraordinarily low design. However,

this type of locomotive is also used wherever heavy standards gauge locomotives cannot be employed for geological reasons. In principle, the 75-ton locomotive can be supplied in two different types: with high-voltage control and high-voltage cam-type controller on the one hand and with contactor control



*Elektrische Industrie-Lokomotive EL 2, 100 t
Dienstgewicht (Deutscher Bergbau)*

on the other hand. The latter type is suitable for multiple-unit control, i. e., two locomotives can be controlled from one driver's stand. This contributes substantially to an increase in the efficiency of transport as well as of the productivity of labour. The contactor-controlled locomotive is externally distinguished from the other type by a forecab running on a level with the roof of the central driver's stand unto the end, this forecab being necessary of housing the voluminous electrical equipment. The mechanical part of both types is welded and made from solid mild steel plates. The locomotives are equipped both with a compressed-air brake and an electric rheostatic brake, the electric brake being designed for downhill braking on a gradient of 30% and 1.5 km (abt. one mile) long. Both types are provided with four externally ventilated nose-suspended traction motors having a one-hour rating of 185 kW each so that a tractive force of 10.5 tons at a speed of 24.7 km (15.3 miles) per hour will be developed with a total one-hour rating of 740 kW. The admissible maximum speed is 50 km (31 miles) per hour, the maximum starting tractive force at a coefficient of adhesion of .33 amounting to 23.5 tons.

More than 500 of these locomotives have been set to work since 1950 and nearly 450 out of them were supplied to the German mining industry.

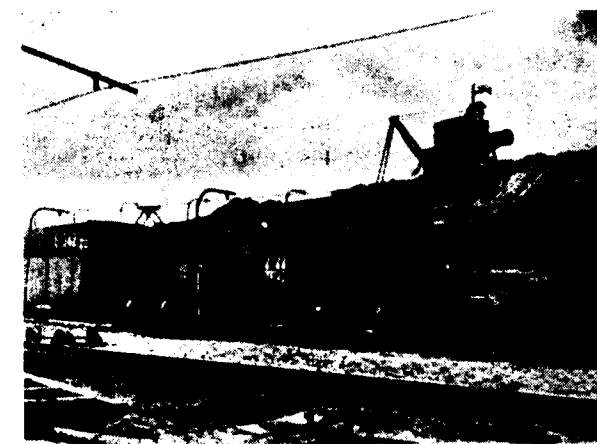
The 100-ton type is a bogie locomotive Bo' Bo' which is most employed in all countries. Special mention may be made in this connection of one locomotive out of the various designs of this type which leave the locomotive building factory at Hennigsdorf in large lots. The type in question is the two-voltage locomotive which was developed for the German lignite mining industry. This locomotive is built for standard gauge (1435 mm = 4' 8 1/2") and trolley wire voltages of 1200 and 2400 volts d. c. The locomotive can be changed over from the one to the other trolley wire voltage by changing the terminals in a shop within a few hours. This means that the locomotive can be used both in older open-cut mines with a trolley wire voltage of 1200 volts and in the new mines with a trolley wire voltage of 2400 volts and that one locomotive can be transferred from one open-cut mine to another if required. Like all other locomotives of this size it is equipped with contactor control and suitable for multiple-unit control. Four externally ventilated 350-kw nose-suspended series-wound motors with commutating poles and compensating winding are used as driving motors. They are equipped with double-sided helical gears which has proved to be most suitable in the severe overburden operation. The bogies of this locomotive are short-coupled so that all tensile forces, impact



*Elektrische Industrie-Lokomotive EL 1,
150 t Dienstgewicht*

forces, and shearing forces are absorbed by the bogies. This means that the upper frame which is spring-mounted to the bogies has to absorb the acceleration forces only. All apparatus and control elements necessary for operating the locomotive are

housed in the upper frame. The central driver's cab is very spacious and end as well as side windows ensure good visibility to all sides. The switch-gear is housed in special switch cupboards arranged in the driver's cab beside the two driver's stands so that



*Elektrische Industrie-Lokomotive EL 3,
75 t Dienstgewicht*

easy maintenance of the switchgear is guaranteed. The front casings disposed before and behind the driver's cab contain the other electrical and pneumatic equipment. They are accessible for maintenance and inspection purposes by doors from the driver's cab. The front casings are covered with hoods which can be removed for more extensive repair work and thus facilitate the access to the various units.

The entire mechanical part of this locomotive is also welded. The electric rheostatic brake installed in this locomotive in addition to the usual compressed-air brake is designed for downhill gradients of 30/0 up to 2 km (abt. 1.2 miles) long. The locomotive can be equipped with a train towing device if so desired so as to ensure continuous loading of the whole train by remote control of the locomotive from a large-size unit.

The other types of the 100-ton locomotives are designed in accordance with the same principle. They are chiefly distinguished from each other by the trolley wired voltage, the gauge and the different types of the auxiliary equipment such as trolley contacts, compressors, controlling current converters, lighting, safety devices etc. so as to meet the various specifications of the customers.

The total one-hour rating of motors of 1400 kw enables the 100-ton locomotive to develop a speed of

30 km (19 miles) per hour, the tractive force obtained being 16.5 tons. The admissible maximum speed was fixed at 65 km (40 miles) per hour. The maximum starting tractive force at a coefficient of adhesion of .33 is as high as 30 tons.

The factory was able to supply up to the present nearly 450 of these locomotives to the Soviet Union, China, Poland, Bulgaria, and to the German mining industry. The constantly increasing number of orders for this very type of locomotive reveals that it becomes more and more popular.

The 75-ton and 100-ton locomotives contribute decisively to the annual extraction in the German lignite industry which totals 260 million tons and is unrivalled in the world.

The twelve-wheel 150-ton locomotive is an interesting new development of the last few years. Its service weight can be increased to 170 tons. In contrast to the formerly usual design as an articulated locomotive this locomotive is a bogie locomotive Bo' Bo' Bo'. In principle, its design is adapted to that of the 100-ton locomotive. Thus quite a number of parts and devices are of the same construction and interchangeable. A novel feature of the locomotive is the split upper frame, the two parts being spring-mounted to the front and to the rear bogie respectively and jointly spring-mounted to the centre bogie. Thus it was possible to essentially improve the running properties of the locomotive and to considerably

reduce the wear of the wheel flanges. Each one driver's stand is arranged in the front and at the rear of each section of the upper frame followed by a spacious machine room. Both driver's stands are connected with each other by a central gangway leading through the two machine rooms and ensuring good accessibility to the machines contained therein. Six 350-kw motors are used as driving motors. The contactor control in this locomotive is also provided for multiple-unit control so that a total locomotive weight of 300 tons can be employed in severest overburden operation. It should be mentioned that this locomotive is fitted with external ventilation of the starting and braking resistances so that the electric rheostatic brake can be used for downhill braking on gradients up to 30/0 and up to 12 km (abt. 7 miles) long. Thus this locomotive is the most efficient industrial locomotive in the world. The six motors of this locomotive develop a tractive force of 24.7 tons at a speed of 30 km (abt. 19 miles) per hour. The maximum starting tractive force amounts to at least 45 tons at a coefficient of adhesion of .33. The maximum speed of 65 km (40 miles) per hour corresponds to that of the 100-ton locomotives.

Most of these locomotives have been supplied to the Soviet Union which has received more than 200 locomotives up to now. Further locomotives were supplied to the People's Republic of China. Orders for more than 200 locomotives of this type are already in the books and will be executed during the next few years.

DIESEL-ELECTRIC EQUIPMENT FOR NEW RESEARCH SHIP

Associated Electrical Industries Ltd. is to supply all the diesel-electric propulsion machinery, auxiliary generator sets and electric drives for the winches for the new National Institute of Oceanography research ship. The order, which includes Ruston and Hornsby engines to drive the main and auxiliary generators, has been received from Hall, Russell and Company, at whose Aberdeen Yards the new vessel will be built. The main propeller will be driven by a 2000-s. h. p. 190-r. p. m. direct current double-unit motor, the two armatures of which will be connected in series with the armatures of the three 610-kV, 500-r. p. m., 504-volt main generators. The scheme is based on the AEI constant-current system, and the motor can be controlled from three positions in the bridge or from the switchboard in the engine room.

The 350-s. h. p. bow propulsion motor and the two 100-h. p. winch motors will also be fed from the constant-current loop, the bow propulsion motor

being controlled direct from the bridge or from the engine-room and the winch motors locally.

Each main generator set will include a 200-kW, 220-volt d.c. tandem-driven auxiliary generator; two separately driven auxiliary generators each rated 400-kW, 220 volts will also be installed to supply the ship's busbars.

With the constant-current system all or any of the main Diesel-generator sets can be used to supply the main propulsion motor, bow propulsion motor and winch motors simultaneously, while at the same time independent control is provided for each motor. The main circuit current is maintained at a constant value by means of an amplidyne exciter, speed variation of the propeller motor being obtained by varying its field and hence its torque; adjustment of the motor field is carried out automatically by the propulsion motor exciter to give the propeller speed predetermined by the controller setting.

REFUELLING OF DIESEL LOCOMOTIVES

By E. L. Knowelden*

REFUELLING WITHOUT SPILLAGE

THE increasing use of diesel locomotives and the need to refuel them as rapidly as possible to obtain maximum utilization has brought with it refuelling problems.

When the percentage of diesel engined stock was small, refuelling was usually the concern of one man who was able to devote sufficient care and attention to ensure that such spillage was minimised. However, with larger numbers of locomotives requiring replenishment at an establishment with multi hose points, it has been found impossible to prevent considerable quantities being vented. The usual practice of filling until fuel issues from the vents is highly undesirable, but is understandable when one considers that the air space will perhaps be as low as 2½% of tank capacity and gauges totally inadequate to detect the fuel level in time to either shut down the pump or disconnect the self-sealing coupling.

Such spillage brings with it many disadvantages. The obvious fire risk can be guarded against to some extent if sufficient regulations can be enforced, but the disfigurement of the refuelling installation leads to the shifting of track ballast and the eventual pollution of streams and drinking water, together with the psychological disadvantages of personnel working in dirty surroundings which leads to slovenly maintenance. The cost of the fuel saved is of course considerable and usually shows up as a sudden improvement in fuel consumption figures when quantities are booked to individual locomotives. A valve will save its own cost in fuel in six months on a main line locomotive which is fuelled once per day.

If the locomotive has a connected tank system it is impossible to fill all tanks at a uniform rate even with large dia balance pipes. The manufacturing tolerances present in the various refuelling galleries, bends, elbows etc., mean that one tank at least will lag behind the remainder. We have proved this point by rig testing with piping manufactured under close tolerances conditions. It is therefore

*General Manager, Alan Cobham Engineering Ltd., England.

essential for locomotives having several fuel tanks to fit Refuelling Control Valves.

These problems are not peculiar to locomotives and have been met and overcome by my own company for example in a variety of installations commencing with the refuelling of the "Empire" Flying Boats in 1937. These aircraft were the first to be refuelled through self-sealing couplings and, as may be expected, suffered from venting problems due to asymmetric pipe runs. The solution was found to be float controlled tank mounted shut-off valves. Subsequently all military and commercial aircraft were fitted with similar valves making spillage a thing of the past. Similar spillage problems were encountered on naval coastal craft, luxury yachts, oil installations and static fuel tanks and were solved with Refuelling Control Valves. It has been estimated that twenty-five thousand valves of our design and manufacture shut off every day.

One cannot, however, take an aircraft valve or a boat valve and indiscriminately apply it to locomotives. It is no use fitting an aircraft valve and assuming that it possesses sufficient strength merely because it will withstand 10g. shock loads. It can be used but must be made sufficiently robust to withstand heavy handling during fitting and above all it must be foolproof since inspection standards for locomotives are different to those used on aircraft. Shock loading in the region of a locomotive fuel tank rarely exceeds 1g. whereas fitting vehicles are in the neighbourhood of 2g. and high speed launches, when planning in rough weather, are about 4g. However, shock loads are only half the problem since locomotives are subject to low frequency, high amplitude vibration and this must be taken into account when designing valves.

Valves were first fitted to an 0-6-0 diesel electric shunter of British Railways, Midland Region, in 1956 and were later fitted to all types of mainline locomotives of British Railways—(Type 1, 2, 3, 4 and 5). A British Railways railcar has also been fitted with valves, but in general it is overseas railways that have led with the fitment of Refuelling Control Valves to railcars.

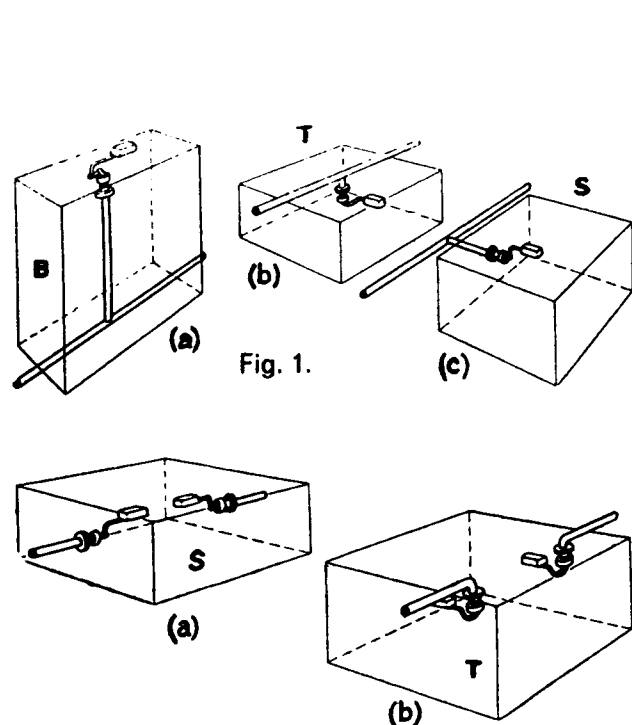


Fig. 1.

Fig. 2.

Where refuelling is through an open orifice similar to those embodied in road vehicle fuel tanks, it is not possible to attach a valve to the filler cap and utilise the existing trigger nozzle. The method adopted in these cases is to add a self sealing coupling and Refuelling Control Valves adjacent to the existing filler cap in order that the rolling stock may utilise either method of replenishment. On a long train containing many motor units and consequently many widely spread fuel tanks, it would be possible to fit a gallery running the entire length and refuel all tanks from any one filling point.

Refuelling Control Valves can be built into new rolling stock or may be added to existing stock. With the large range of available valves little or no alteration is required to existing systems, although two valves are sometimes required compared with one where valves are considered at the design stage.

The simplest system is a single tank with dual refuelling points. Three possible solutions are shown in Figure 1.

Due to space limitations, it may not be possible to fit the cross feed pipe, and Figure 2 presents a solution.

Filters have not been shown, and, although the valves will cope with particles up to 350 microns in

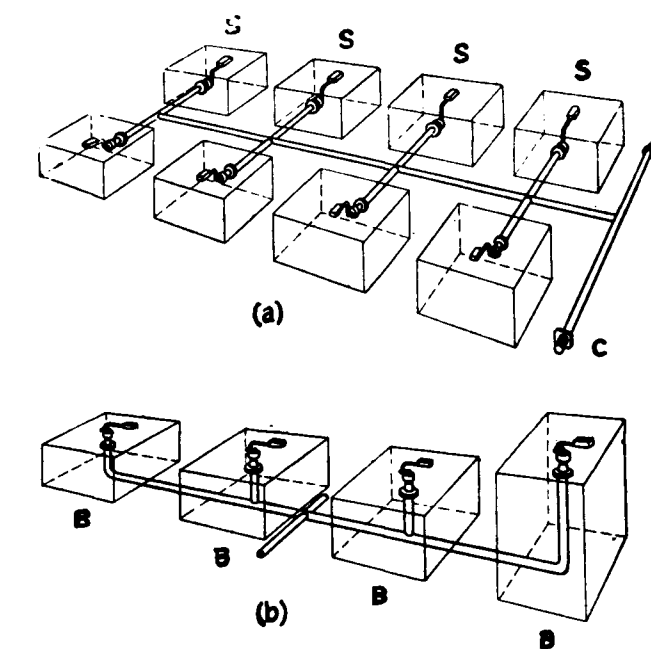


Fig. 3.

considerable volume and are unaffected by normal scale, the usual practices should be followed to safeguard the engine supply. Filters can be placed just after the self-sealing coupling, or, if accessible, a single filter can be used in the line between the tee and the valve.

Where a screw down gate valve is considered for fitment after the filter to prevent spillage during filter changes, it is suggested that a leak-tight, non-return valve, supplied by Alan Gobham Engineering Limited is installed—thus rendering this an automatic operation.

The pipe line between the self-sealing coupling and the Refuelling Control Valve will be full of fuel when the valve shuts, and the refuelling coupling disconnected. As the tank's fuel is used the float will drop, and if the pipe run from the coupling to the valve is downhill, the fuel in this pipe will drain into the tank. As with every pressure refuelled system air locks can be ruled out—they cannot occur.

In a multi-tank system each tank should be fitted with a valve fed from a common refuelling gallery connected to refuelling couplings on either side of the locomotives. Two possible systems are shown in Figure 3.

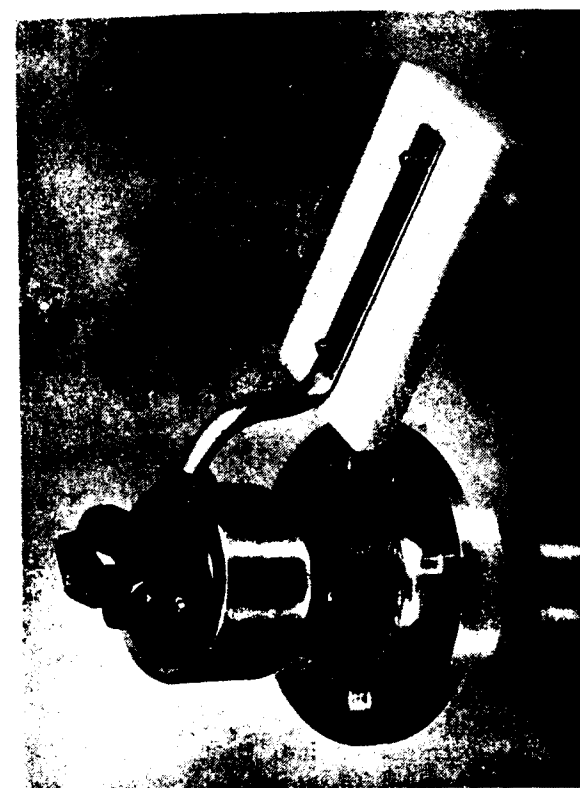
The refuelling rate and type of pump will vary from installation to installation. The simplest possible is to have an overhead tank and refuel by gravity. This method is perfectly suitable and a 20 ft. head should be aimed at if possible. However, if one is planning a new installation and spillage is impossible whatever the flowrate, due to valves being fitted, it is possible to consider higher flowrates and pumps having a capacity of say 70 gallons per minute are frequently found. These pumps should preferably be of the centrifugal type since they will be unaffected by a sudden stoppage on the outlet. The tank mounted Refuelling Control Valve shuts in one second and the pump relief valve must be adequate. A surge pressure (hammerblow) is generated by the valve closure and this pressure is additional to the relief valve setting or the stall pressure of the pump. Typical pump refuelling pressures are in the order of 30 p. s. i. This pressure is dependent on the velocity of flow and the mass of fuel in the line and in practice does not give rise to problems.

open orifice air escapes from the orifice as the fuel is fed in and with the filler cap closed a small vent pipe allows air to enter during running. With a pressure refuelled system the problem of venting is similar, whether valves are fitted or not, except that with valves fitted the probability of the vents being used is enormously diminished. The vents exist for two purposes; firstly to carry away the displaced air during refuelling and admit air during running and secondly to carry away fuel in the event of too much entering the tank. Since the tank pressure, in the event of the vents carrying fuel, will be equal to the pressure drop over the vent pipe (including entry and exit losses) at the rate at which fuel is entering the tank it is particularly important that they should be adequate. Since most pressure refuelling systems use $1\frac{1}{2}$ " bore pipe it will usually be found that 18" of vertical $1\frac{1}{2}$ " pipe is sufficient. This vent should have a gauze and mushroom head to protect the tank against fire and foreign bodies respectively.

Before selecting the most suitable valve from our existing range, to apply to locomotives, discussions were held with all British manufacturer and users and it was decided that a valve must be capable of fitment at any angle within the tank if the maximum freedom was to be given to the locomotive engineer. Three variants were therefore made available for top, side, bottom or intermediate tank positions. A fourth type, in which the valve is fitted to the base of a tank and the float unit at the desired cut-off level, has been in service with British Railways since 1957 and can be used should the standard versions be unsuitable. All the valves will withstand shocks and vibration encountered when the valve is unsupported by fuel.

A valve mounted close to the top of a tall fuel tank will cause the fuel to fall as droplets and the possibility of foaming, or a build-up of static electricity, under these conditions may be neglected with locomotive fuel tanks. The use of such a valve with large un baffled static tanks should be avoided and a bottom mounted version used instead. Valves should not be mounted where they are free to discharge through the vents.

From the above it will be seen that Refuelling Control Valves have progressed far beyond the trial installation period to the position where they are beginning to be universally accepted as standard equipment. Perhaps we should be grateful for a piece of standard equipment that actually saves money rather than a piece that "gilds the lily".



Refuelling control valve.

When fuel is pumped into a tank air must be allowed to escape and equally well as the fuel is used air must be allowed to enter the tank. This is briefly the essence of all venting problems. With an

Torque Converters can be Different

By J. B. Black and M. W. Dundore

Twin Disc Clutch Company, Hydraulic Division
Rockford, Illinois

The paper "Converters Can Be Different" was written to point out the principle basic differences between hydraulic torque converters of various significant types.

The following converter designs are described and compared in terms of fundamental design and operating characteristics when combined with a typical internal combustion engine power source.

- a. Three Stage Converters
- b. Single Stage Converter Couplings
- c. Single Stage Outflow Stator Type
- d. Single Stage Inflow Stator Type
- e. Single Stage Stationary Housing High Utility Ratio Converter

The subjects discussed in connection with these various types are basic theory, vane velocity vectors and their influence on torque absorption characteristics, utility ratio, counter head, shutoff, torque equation factors affecting capacity, speed effect on capacity, effect of impeller absorption curve shape on engine speed characteristics, split torque effect on engine lug down, high speed ratio converter characteristics, flow head comparisons, converter cooling, push start devices, converter cranking characteristics, and converter braking.

Emphasis is made on the necessity for the Equipment Manufacturer to thoroughly evaluate the many different types of converters available. This evaluation can be done by means of a mathematical determination of resultant vehicle performance derived from the use of the various converter absorption and power transmission characteristics.—AUTHORS.

CONVERTERS CAN BE DIFFERENT

THE art of hydraulic torque converter design has progressed during the last twenty years to the point where the industrial equipment manufacturer is faced with a more or less bewildering array of torque converter types. Each type has its own set of operating characteristics inherently imbedded in its physical design. The discerning manufacturer, desiring to produce equipment which will transmit the greatest amount of available horsepower, is faced with the problem of determining the relative merits of all the industrial types of converters on the market.

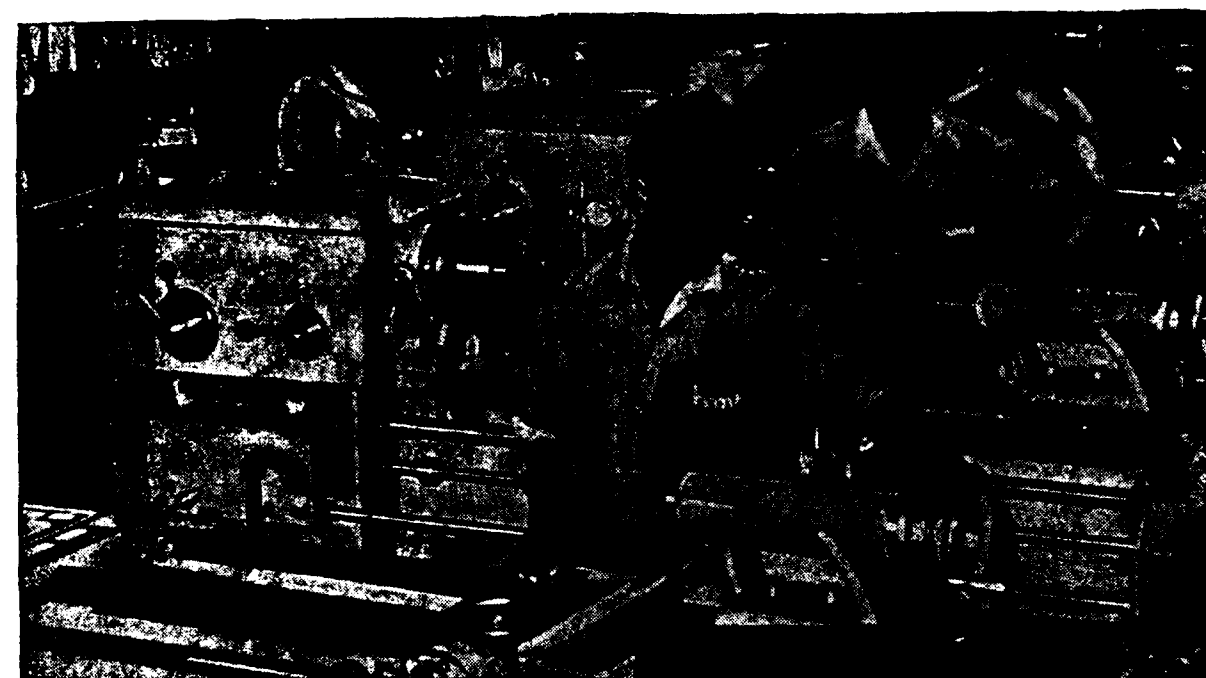
This process of evaluation is most efficiently accomplished when the manufacturer sets up a design group within the Engineering Department which can prepare a detailed mathematical analysis of output performance with the cooperation of the various torque converter manufacturers. These studies include the calculation of output horsepower, output torque, engine RPM, efficiency, heat rejection requirement, drawbar pull, and other performance factors over the

whole operating range. From these studies, comparative performance curves can be drawn up for the various types of converters that can be invaluable in determining which direction immediate and long range planning should take.

This combined technical exchange between the vehicle design engineer and the converter engineers has proven to be extremely successful. The vehicle designer has begun to master the torque converter as a tool in the same sense that he has learned to use the internal combustion engine, the transmission, and the final drive to translate power into work accomplished on the ground. At the same time, the converter engineer has been placed into closer association with the performance problems of the ultimate users which vary greatly from the tractor to the shovel to the end loader to the off highway truck.

This paper, therefore, has been written to attempt to show some of the many considerations facing these joint analysis groups as they view the various types of converters offered on the market today and

HINDUSTAN MACHINE TOOLS rely on CARBORUNDUM UNIVERSAL ABRASIVES for all grinding operations



"Precision grinding is an all important part of machine tool production, and Carborundum Universal Grinding Wheels, which permit grinding to close limits of accuracy and with fine surface finishes, are helping us to produce better quality precision products."

—HINDUSTAN MACHINE TOOLS LTD.
BANGALORE.
(A Government of India undertaking)

In any industry... for any grinding operation...

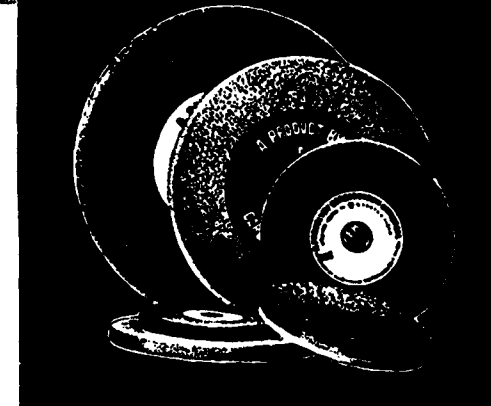
you can rely on Grinding Wheels made by

CARBORUNDUM UNIVERSAL LTD.

Head Office: 52/53, Jehangir Street, Madras-1 Telephone 29141 (8 Lines)
Works: Tiruvottiyur

Distributors: MESSRS. WILLIAM JACKS & CO., LTD.,
Calcutta-1, Bombay-1, Madras-1, New Delhi, Bangalore-1, Kanpur, Hyderabad.

For Specialties only: MESSRS. H. S. COX & CO., PRIVATE LTD., 24, Rampart Row, Bombay.



We now manufacture
CARBOFLEX Reinforced Depressed
Centre Wheels for foundries and for
weld dressing operations



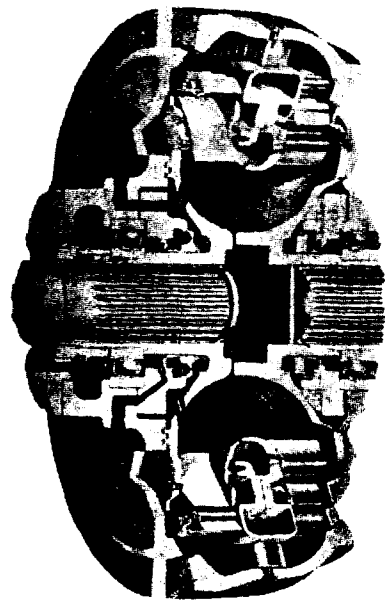


Fig. 1. Twin Disc 3 Stage

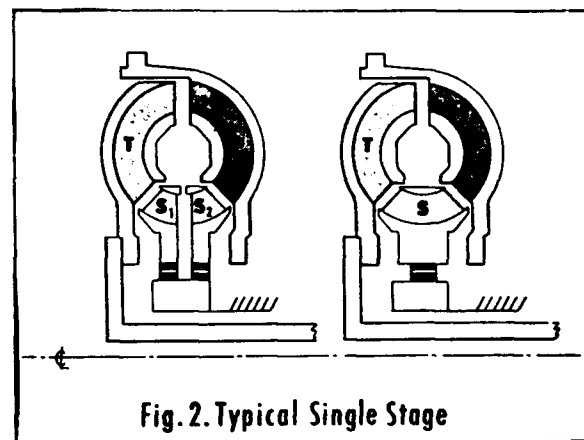


Fig. 2. Typical Single Stage

to attempt to explain the reasons behind the performance characteristics peculiar to each.

In the early years of American industrial converter application, that is in the 1940's, there were only two major types of converters available for consideration. One was the three stage converter of the Lysholm-Smith design, which consisted of one impeller wheel, a turbine wheel made up of three separate vane stages, and a fixed or stationary housing containing two sets of stator vanes, see Figure 1. The second major type of converter, Figure 2, was the single stage converter consisting of a single impeller, turbine, and stator or stators, and a rotating housing.

Now, however, other single stage converters are

making their way into the American and the world markets which have such radically different performance characteristics that we can by analysis and examination demonstrate most of the principles of converter operation and thereby prove that—Converters Can Be Different.

In the past few years, we have all been made aware of the more or less obvious differences from one type converter to another by the many papers that have been presented before SAE and other technical groups. These have included the single stage, two stage, and three stage converters identified by the number of turbine stages. We have been introduced to the terms "single phase" and "poly-phase". A single phase converter is one in which the impeller is fixed to the input shaft, while the turbine stage or stages are fastened permanently to the output shaft. The stator stage or stages are fixed to the ground through a housing or ground shaft attached to the housing. The poly-phase, by contrast, has one or more blade stages attached to its respective shaft or the housing by means of a freewheel or some other type of clutch mechanism and may include gearing. This element fixes the motion of the blade stage with the housing or shaft during part of the performance cycle and allows it to float freely or turn in a geared relation during the remainder of the cycle.

Examining the various types of single stage converters, we will bring to your attention the more subtle differences which will directly affect the overall picture of performance when these units are applied to the most common of the power sources, chiefly the diesel or gasoline engine.

BASIC THEORY

To better understand the manner in which the torque converter functions, it will be helpful to review a few basic hydrodynamic principles. First of all, the basic converter element is a rotating wheel with vanes attached which operates submerged in fluid. Forces are transmitted from an impeller connected to a source of power to the fluid or from the fluid to the turbine by force components which lie in the direction of the runner motion, that is, components that are in a peripheral direction. A hydrodynamic transmission, then must have at least two of these elements in which the transfer of power between the input and output runners is by means of the mass effects of the fluid. In general, the passages between the vanes are fairly large and continuous, thus the

pressure differences within the runner are not due to positive displacement action. Also, the fluid passages are large enough to eliminate the possibility that viscosity effects will have a deciding influence on the forces acting on the runners.

Thus, the controlling forces are due primarily to the mass effects of the fluid or the following well-known formula applies.

$$F = MA \text{---(1)}$$

In turbomachinery, this law is expressed in the form

$$F = M \frac{dv}{dt} \text{ or } F \Delta t = M \Delta v \text{---(2)}$$

Since the principle motion of the runners is rotational, the forces that cause a transfer of power between the runner and the fluid lie in the direction of motion or tangential. Consider the diagram for a radial flow impeller, Figure 3. As the fluid is propelled from R^1 to R , the flow velocity changes from V^1 to V . The tangential components or torque producing components change from S^1 to S . The

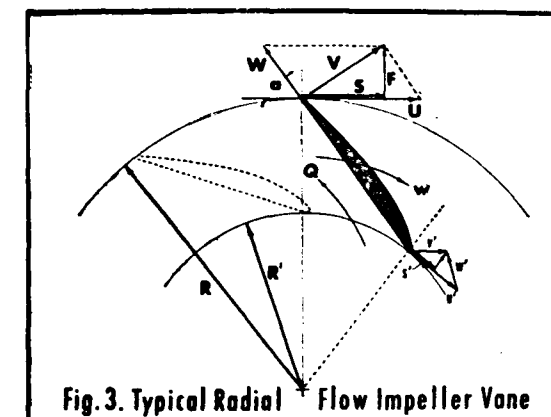


Fig. 3. Typical Radial Flow Impeller Vane

vectors shown for V , etc., represent velocity in feet per second.

U represents the peripheral velocity at the outlet tip of the vane identified as the Radius, R , times the angular velocity, w .

W represents the approximate exit relative velocity direction of a fluid particle leaving the vane and being influenced by the vane angle itself.

V represents the absolute velocity of the particle or the resultant of the peripheral and relative velocity vectors.

S then is the tangential component of the absolute velocity or the vector component lying in the direction of runner motion.

F is the torus flow velocity or transportation of flow.

The direction of relative velocity is determined in general by the vane angle while its magnitude depends on the flow Q passing through the vane.

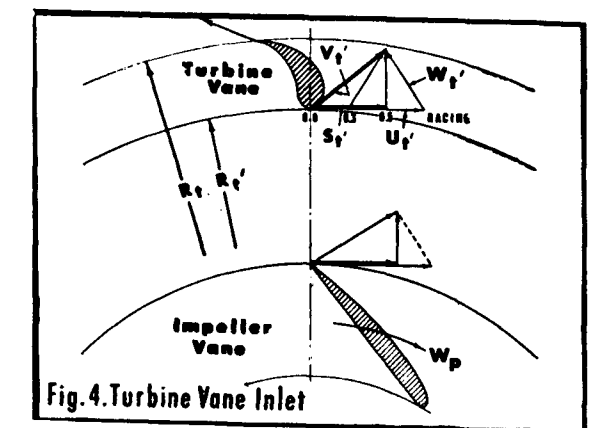


Fig. 4. Turbine Vane Inlet

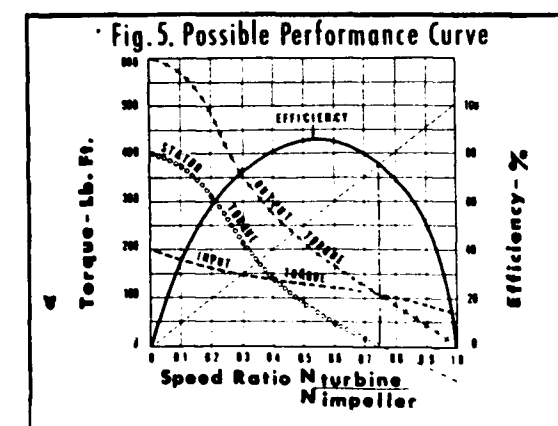


Fig. 5. Possible Performance Curve

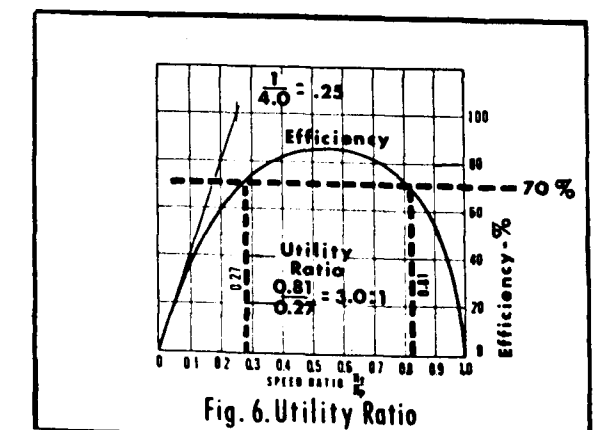


Fig. 6. Utility Ratio

If the channel between two vanes is considered as a form of a rectangular pipe, it is obvious that the flow and velocity then will vary with the flow area.

If no vanes are present in the flow channel and only a change in radii takes place, the product of the tangential component S times the radius R remains constant. This is referred to as the "law of constant angular momentum." Now, if a torque is applied to the fluid by means of a vane or set of vanes, a change in the angular momentum takes place. The torque absorbing capacity of the vane element depends on the net change in the angular momentum and the mass of fluid to which this change is made. The torque equation therefore becomes.

$$T = M \Delta SR \text{ or } T = M (S_p R_p - S_p^1 R_p^1) \quad (3)$$

outlet — inlet

$$\text{where } M = \frac{Qd}{g} = \frac{\text{cu. ft.}}{\text{sec.}} \times \frac{\text{lb.}}{\text{cu. ft.}} = \frac{\text{lb. sec.}}{\text{ft./sec.}^2}$$

Q = flow in cu. ft./sec.

d = weight of fluid in lb./cu.ft.

g = gravitational constant, 32.2 ft./sec./sec.

$$\text{or Torque } T = \frac{\text{lb. sec.}}{\text{ft.}} \times \frac{\text{ft.}}{\text{sec.}} \times \text{ft.} = \text{lb. ft.}$$

$$T = \frac{Qd}{g} (S_p R_p - S_p^1 R_p^1) \quad (4)$$

Power, then, is equal to $T\omega$ where ω is the angular velocity in radians per second or $2\pi \times \text{RPM} \div 60$.

$$T\omega = \text{Power} = Q \frac{d}{g} \omega (S_p R_p - S_p^1 R_p^1)$$

$$\text{or Power} = Q \frac{d}{g} (S_p R_p \omega_p - S_p^1 R_p^1 \omega_p^1)$$

Then, since ωr = peripheral velocity U , substituting we have

$$P = Q \frac{d}{g} (S_p U_p - S_p^1 U_p^1) \quad (5)$$

The head of fluid developed in terms of feet per lb. of fluid flowing is

$$\text{Head } H = \frac{P}{Qd} = \frac{1}{g} (S_p U_p - S_p^1 U_p^1) \quad (6)$$

Equation (5) is the standard Eulers equation and as written would represent the theoretical head

imparted to the fluid by a centrifugal impeller. This head is made of three major parts.

1. The pressure rise due to the centrifugal forces acting on the fluid particles.
2. The pressure rise due to the velocity change of the fluid flowing within the vane channels relative to the vane surfaces.
3. The change in kinetic energy represented by the change in direction and magnitude of the absolute fluid velocities.

The similar equation for the torque absorbed by a turbine is

$$T_t = \frac{Qd}{g} (S_t^1 R_t^1 - S_t R_t) \quad (7)$$

inlet — outlet

Equation (5) can be rewritten as follows

$$P = Qd \frac{1}{g} (S_p U_p - S_p^1 U_p^1)$$

$$\text{Thus, horsepower } P = \frac{QdH}{550}$$

$$\text{We also know that horsepower} = \frac{\text{torque} \times \text{speed}}{5252}$$

Equating the horsepower equations

$$\frac{QdH}{550} = \frac{TN}{5252}$$

Solving for T = Torque

$$T = \frac{5252}{N} \frac{QdH}{550}$$

Q = cu. ft. / sec.
 d = lb. cu. ft.
 H = ft./lb. of fluid
 N = RPM
 T = lb. ft.

or in simplified form

$$T = kQH \quad (8)$$

where T represents torque

k —the constant terms

Q —the flow

H —the head

Equation (8) is one of the most fundamental and important equations in torque converter design. It states that if we compare two hydrodynamic machines, using the same fluid at the same temperature and input speed and which give the same torque capacity, i. e., the input runner or impellers of both machines absorb the same torque, then the product of flow times head must necessarily be equal. To expand this still further, we see that the head, which represents the change in momentum, which we stated was a function of the vanes, and the flow representing the mass of fluid moved could vary widely in their individual values as long as their product was equal.

In other words, one converter could have a greater vane effect with a correspondingly lower flow than its comparative unit. This idea has led to the generalized reference to a specific converter as a high head-low flow or a low head-high flow unit. The importance of this relationship to the designer will be explained later.

To separate the hydraulic torque converter, which implies the ability to multiply torque, from any hydrodynamic machine requires the presence in the circuit of a fixed stator stage. This stage fastened to the ground does for the converter what the fulcrum does for mechanical advantage in a lever, i. e., it gives the unit something to push against. Without the fixed stage, the torque transmitted by the output runner would be equal to that absorbed by the input runner. The fixed reaction stage provides torque which is transmitted through the turbine wheel to the output and is equal and opposite to the reaction torque. Thus, the equation for the output torque becomes

$$T_{\text{out}} = T_{\text{in}} + T_{\text{reaction}} \quad (9)$$

Torque ratio of the machine becomes

$$T.R. = \frac{T_{\text{out}}}{T_{\text{in}}} \text{ or } \frac{T_{\text{in}} + T_{\text{reaction}}}{T_{\text{in}}} \quad (10)$$

The torque ratio possibilities of any given unit, then, are a function of the amount of torque the unit will transmit compared to the amount it absorbs from the prime mover. Also the torque ratio depends on the effectiveness of the stator stage or stages. We have seen that the amount of torque that can be absorbed and transmitted is a function of the flow times the head.

PERFORMANCE CHARACTERISTICS

To understand what these conditions imply to the torque converter designer, we must first consider the

characteristic performance of this type of hydrodynamic machine.

Assume for this example that the input speed of the prime mover remains constant as the output shaft varies in speed from zero RPM or stall to a racing speed equal to that of the input runner. Then consider Figure 4 representing the turbine vane following the pump. To preserve the direction of rotation, i. e., to have the output shaft rotating the same direction as the impeller, the turbine vane must have a reactive force in the same direction as the rotative motion of the impeller. The vane would be positioned as shown, and the resultant force of the V^1 inlet and V outlet must be in the direction shown by w_r . Since the turbine is increasing in speed from zero RPM to 1.0 speed ratio, the peripheral velocity $U^1 T$ increases as shown. It can be seen that the relative inlet velocity W^1 changes direction with speed ratio, its angle of attack moving around the vane nose by a considerable number of degrees. The characteristic of each vane is that at some angle, approximately in line with the vane physical inlet angle, i. e., a line tangent to the mean chamber line, the vane will perform with maximum efficiency. Attack angles on both sides of this optimum angle will cause some increasing inefficiency. At adverse attack angles, the fluid has a tendency to break away from the vane surface with resultant energy absorbing swirls. This breakaway is aggravated by roughness or other irregularities on the vane surface at the inlet nose and results in serious loss in performance. Most converters use a basic pressure of 20 to 60 PSI supplied by an external positive displacement pump to suppress this separation.

As the speed ratio changes, it can also be seen that the bending of the fluid by the vane becomes less as we move away from stall until at a point where the relative inlet velocity equals the outlet blade angle, the vane is completely unloaded and will not transmit torque. These two actions can produce the performance characteristics shown in Figure 5 depending on the basic unit.

The input torque shown is the torque absorbing characteristics of the impeller at some given input speed held constant as the output shaft and turbine vary from stall (0.0 speed ratio) to racing runout, shown as 1.0 speed ratio in this example. The shape of the input curve depends on the stage preceeding the impeller and will be explained in detail later on.

The efficiency curve varies from zero at stall to a

peak when flow conditions are at the design point and back to zero at racing. The runout speed ratio of the efficiency curve depends on the speed ratio at which the turbine vanes are completely unloaded and zero torque is transmitted. This point can occur below, at, or above 1.0:1 depending on the converter design. The stator vane attack angles vary similar to those of the turbine vane and at a speed ratio where the relative inlet attack angle into the stator equals the stator vane outlet angle, the stator ceases to produce a reaction torque and the hydrodynamic torque converter becomes a hydrodynamic coupling where input torque equals output torque, reference Figure 5. At speed ratios greater than the coupling point, the force on the stator vane is no longer opposite to the normal impeller and turbine forces and the stator is in the way, reducing the efficiency of the unit. For this reason, it is possible to increase the efficiency above the coupling point by mounting the stator on a one way clutch or freewheel. Thus, when the force on the stator changes from reactive to the same direction as impeller rotation, the stator will automatically float with the general fluid rotation. This would be the second phase of a two-phase converter.

Figure 5 shows graphically how the output torque consists of the input torque added to the reaction or stator torque. It also shows the importance of stator stage design in the multiplication of input torque at low speed ratios.

Stator torque can also be expressed in terms of the general torque formula

$$T_s = \frac{Qd}{g} (S_s^1 R_s^1 - S_s R_s) \quad \text{---(11)}$$

inlet — outlet

Another method of increasing the torque capacity and efficiency in this range would be to shift into direct drive; in other words, lock the turbine and the impeller together by means of a clutch. This would then give engine torque out of the converter at nearly 100% efficiency. The converter would be operating at 1:1 speed ratio. At this time, the maximum efficiency of power transfer will be realized if the stator stage is mounted on a freewheel and allowed to float.

UTILITY RATIO

Converter performance tests have shown that the slope of the low speed ratio portion of the efficiency curve can be represented by a line drawn from the zero torque, zero speed ratio point of the performance curve

to a speed ratio point on the 100% efficiency line that is equal to the reciprocal of the stall torque ratio, Figure 6. This fact is important when considering what is normally the most important single converter characteristic, namely—Utility Ratio. We will arbitrarily define utility ratio as the ratio of the speed ratios where the efficiency of power transmission through the converter is 70% or more. This utility ratio is equal to the highest speed ratio at which the efficiency crosses the 70% efficiency line divided by the lowest speed ratio at which the curve again crosses 70%.

For most industrial applications, be it shovels, tractors, or end loaders, there is a constantly changing load demand which causes the output speed to vary over a wide range from near stall to racing. The chief justification for any hydraulic torque converter is its ability to automatically adjust output torque to load demand variation without any conscious effort on the part of the operator. This ability can be fully realized only if the converter has a sufficiently broad operating range so that the number of transmission shifts behind the converter can be reduced to a minimum.

A measure of the usable output horsepower is represented by the area under the curve of output horsepower plotted versus output speed. This evaluation should, of course, be tempered by the time interval spent in each portion of the curve during the work cycle. Using this yardstick of overall usable power, peak converter efficiency could be second in importance to the total efficiency curve that rises above a predetermined efficiency level such as 70%.

In terms of vane shapes, this means that with the wide dispersion of the approach velocity attack angles into the various converter stages, the design trend has been towards those shapes that will efficiently pass the flow at the widest possible variance from the optimum attack angle. This accounts for the bulbous or bluntly rounded vane noses encountered in converters of wide utility ratio.

In the constant struggle to obtain higher utility ratio, a major design consideration has become obvious and this can be shown by referring to Figure 7. Assume a converter with an efficiency curve with a utility ratio of 2.0 to 1.0. The high end of the curve crosses 70% at 0.8 speed ratio while the lower end crosses at 0.4. If it is desired to improve the ratio to 3.0:1.0 mathematically, we

could hold the low end at 0.4 speed ratio and attempt to develop blading with good high speed ratio performance characteristics. The cross over point for the high end would have to move out to 1.2 speed ratio. A second alternative would be to hold the high end 0.8 point and use blading with good low speed ratio characteristics. We would have to move the lower cross over point back to .267 speed ratio. It is readily apparent that a much smaller gain in low speed ratio performance will produce greater utility than a much larger increase in the high end. It is also apparent by the slope of the efficiency curve that the stall torque ratio will increase considerably when the low speed ratio blading is used. Usually, you will find that converters with wide utility ratios have high stall torque ratios.

It has been a standard axiom that if an application requires peak performance at the high speed ratio end of the curve and the time element in arriving at this speed ratio is small, such as in the automotive field, the converter blading can be designed for a narrow high efficiency range at high speed ratios at the sacrifice of good low speed performance and stall torque perfor-

mance. However, at the present time, we are witnessing a mighty struggle within the automotive converter transmission field to extend the useful range of the converter by such modifications as multiple turbine stages and stator stages that freewheel out of the way under adverse attack angles, variable pitch stator vanes, and multiple turbine stages that multiply torque through the use of planetary gear sets.

Full understanding of converter operation requires an examination of the torque absorption curve of the converter impeller.

To understand the influence of blading on the torque curve, we must return to the basic torque equation

$$T = Q \frac{d}{g} (S_p R_p - S_p^1 R_p^1) \quad \text{---(4)}$$

and to the statement that the whirl (S R) remains constant in a vaneless space. This means that this outlet whirl (S R) of the stage immediately preceding the impeller is equal to the inlet whirl of the impeller.

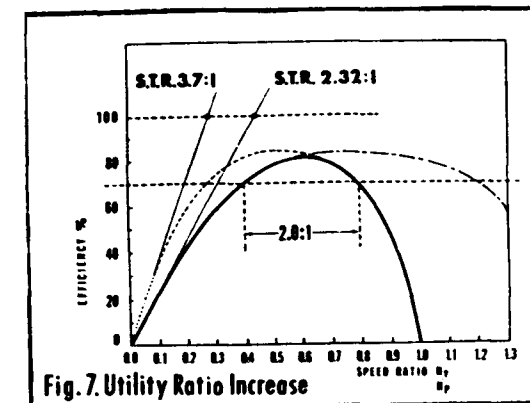


Fig. 7. Utility Ratio Increase

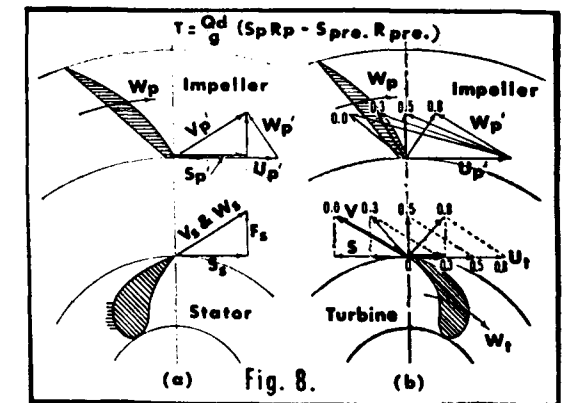


Fig. 8.

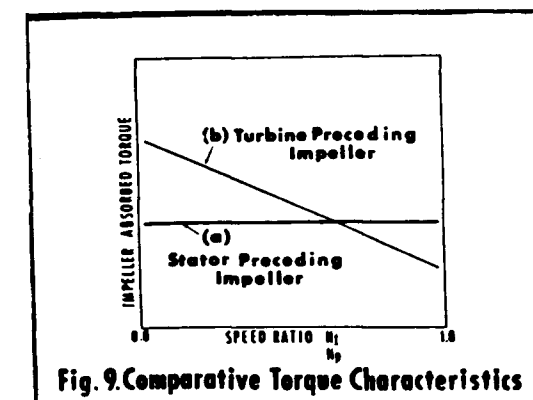


Fig. 9. Comparative Torque Characteristics

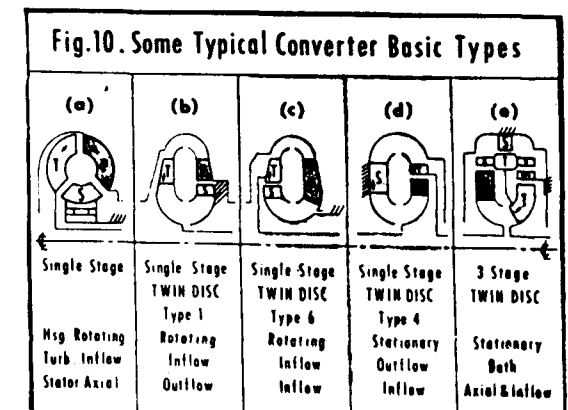


Fig. 10. Some Typical Converter Basic Types

$S R$ preceding = $S^1 R^1$ impeller

Thus, the torque equation could be rewritten

$$T = Q \frac{d}{g} (SR \text{ impeller} - SR \text{ preceding stage}) \quad (12)$$

This makes the preceding stage a critical one in terms of impeller performance. If the preceding stage is a rotating one, that is a turbine, the torque curve will rise from racing to stall. If the preceding stage is a stationary one, such as a stator, the torque characteristic will be more or less flat. Figure 8 (a) shows in its simplest form how a constant whirl would leave the stator at all speed ratios assuming a constant flow condition, which actually does not exist as will be pointed out later. Assuming also that the impeller remains at a constant speed at all speed ratios, which could be achieved in a dynamometer test, the impeller absorbed torque will tend to remain constant giving a flat curve. Under the same assumption, Figure 8 (b) shows the effect of a variable speed turbine vane "feeding" the impeller. At stall with zero peripheral velocity and a backward curved vane, the resultant tangential component of the absolute velocity S is in the opposite direction to the normal rotation and is therefore considered negative. The whirl SR is therefore negative and when entered in the torque equation gives a plus value to the inlet whirl. This results in the maximum value for the torque. As the turbine begins to rotate, the whirl changes from negative to positive and increases in magnitude, thereby decreasing the value for torque. This gradual and continuous unloading of the impeller results in a torque curve (b) in Figure 9. This is somewhat the shape of the curve of a three stage Twin Disc converter. Figure 9 (a) shows the flat curve of the stator preceding the impeller.

In actual practice, the flow of the three stage is comparatively constant at the speed ratio changes. However, the flow through certain types of single stage converters decreases rapidly from stall to racing.

TURBINE COUNTER HEAD

This brings up another major consideration in design of any single stage converter, namely the position and the size of the turbine stage relative to the impeller. We have stated previously that a vane system rotating builds up a head which tends to propel the fluid outward by the centrifugal forces acting on the fluid particles. This force depends

entirely on the rotational speed. In converters of the inward flow turbine type, such as those shown in Figure 10, (a), (b), and (c), although the flow is being forced through the turbine inwardly, the turbine, as it picks up speed, builds up a counter centrifugal head which opposes this inward flow. The maximum flow occurs when the turbine is stalled and it gradually decreases with increasing turbine speed until the turbine head equals the impeller head and the flow ceases. This decreased flow tends to *reduce* the torque absorption of the impeller. However, as the flow decreases, referring to Figure 11, so does the absolute velocity leaving the stator stage. This means that the impeller inlet whirl will decrease tending to *increase* the impeller torque. As this decreasing plus increasing tendency varies in net effect, the theoretical flat input curve is modified approximately as shown in Figure 12. At the stall end, the curve can fall off as shown by Figure 12 (a) or actually rise as shown by Figure 12 (b). The actual characteristics will depend on the converter design.

Shortening the impeller vanes and changing the stator from basically axial to radially outflow as shown in Figure 10 (b) decreases the centrifugal head of the pump relative to the turbine counter head. The rotating mass of oil contributing to turbine counter head extends down to the center of the circuit and not just to the vane inner diameter. This causes the flow shut off to occur at a much lower speed ratio and results in a sudden drop in both input torque absorption and in output torque shortly after passing the clutch point or 1:1 torque ratio point. This rapid unloading of both the prime mover and the output shaft can be useful in certain applications where it is desired to limit the top speed under light load conditions without the use of an output shaft governor. In contrast to an output shaft governor, which has to sense an overspeeding condition and then reduce engine output by closing down the throttle, which takes some time, the sudden unloading of the output shaft which occurs based on speed ratio corrects the overspeeding as soon as it occurs by reducing the high torque causing the overspeeding.

Moving the stator to the other side of the circuit as shown in Figure 10 (c) reduces the turbine counter head by increasing the inner diameter of the rotating oil mass. At the same time, if the impeller vanes are lengthened, the centrifugal head effect of the impeller is increased. Thus, the angular velocity of the turbine must now exceed that of the impeller by some amount before shut off can occur. This increases the

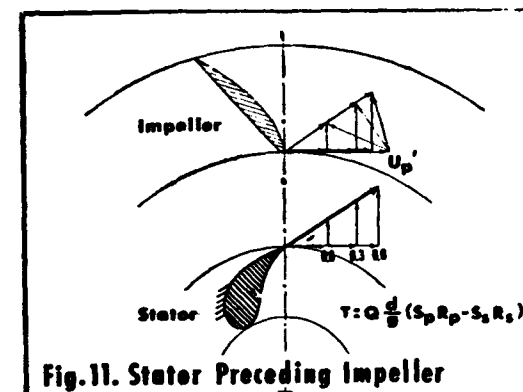


Fig. 11. Stator Preceding Impeller

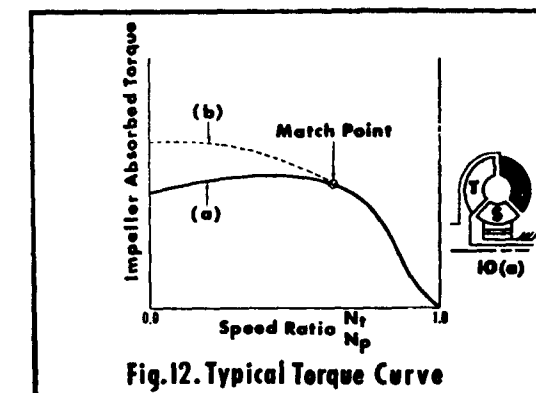


Fig. 12. Typical Torque Curve

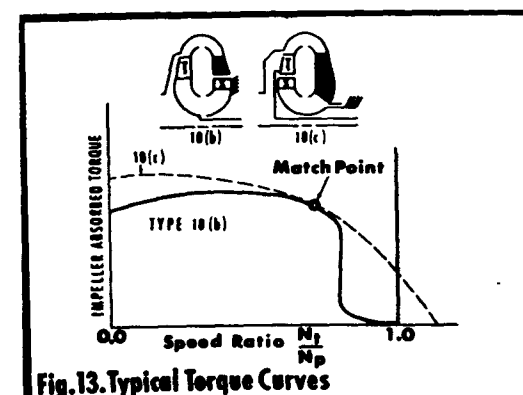


Fig. 13. Typical Torque Curves

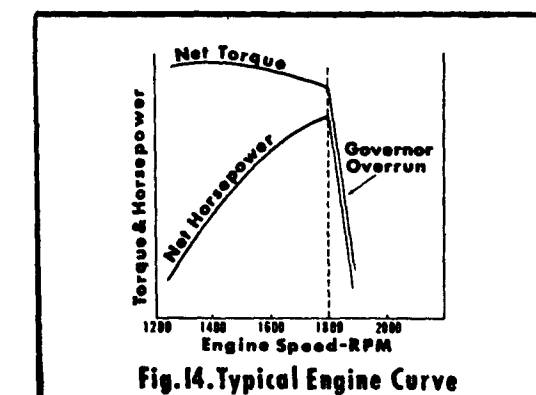


Fig. 14. Typical Engine Curve

runout RPM and therefore the delivered horsepower at high speed ratios. The comparative characteristics of these two types is shown in Figure 13.

The importance of the converter characteristics can be understood better when a combination of the engine and converter is considered.

For a given engine: we would need a converter whose impeller would absorb the engine net full load rated torque at the matching speed ratio point. The engine curve itself would resemble that shown in Figure 14. This is the normal diesel engine curve of torque plotted against engine RPM.

CAPACITY FACTORS

To provide a converter whose impeller absorbs or matches this torque, we can again return to the torque equation.

$$T = Q \frac{d}{g} (S_p R_p - S^1_p R^1_p)$$

We have already seen how the vane stage ahead of the impeller can affect the impeller's torque absorbing

capacity through its influence on the

$$S^1_p R^1_p \text{ whirl value.}$$

Analysing the equation, we can see several other factors which could affect capacity. They are the quantity of flow, Q ; the weight of the fluid, d ; the outlet velocity component, S ; and the radius, R .

In general, weight and viscosity go together and since fluid friction losses within the blade channels increase with increasing viscosity, it is to our advantage to use the lightest possible fluid with the greatest possible specific gravity. This immediately suggests water, but water has too low a boiling point which, if used in a converter, would give severe cavitation losses in low pressure areas of the circuit in spite of converter basic pressure. Incidentally, one of the earliest applications of a hydraulic torque converter, as described to us by Professor Wilhelm Spannake, was a ship propulsion converter for the Kaiser's yacht which used sea water for the fluid medium. A major requirement which water cannot fill is that of lubrication.

In many converter designs, the converter circuit, the clutches, and the transmission and cooling are tied together with a common fluid which is SAE // 10 or transmission fluid type A. When the fluid circuit is separated from the lubrication system by means of face type seals, usually carbon rings running against steel rings, a light fluid, such as kerosene or a special torque converter fluid, can be used. Since the overall weight difference between the lightest and the heaviest of the customary fluids is relatively small and a given design might not be flexible enough to use a choice of fluids, the weight factor in matching converter to an engine can be eliminated.

Control of the vane channel area giving various flow rates, Q , could be used for changes in torque capacity. However, all areas in the circuit must be changed to maintain some given area relationship which has been determined as giving the optimum overall operating characteristics in the test model. Also this type of change can greatly affect unit tooling costs unless the unit is predesigned to enable the flow area to be modified. A converter of this type produced in this country uses a laminated pattern which enables a unit of a given size to be cast in three different capacities maintaining the same identical vane angles and shapes but varying the flow areas proportionally in each stage. This variation covers a horsepower range of about 1.6 : 1.

The outlet velocity component S_p is one of the major control items. This value can be affected as shown in Figure 15 (a) and 15 (b). For the same peripheral velocity, that is at the same rotative speed, the greater the outlet angle of the vane, the larger the tangential component, S , will become. Thus, once a unit size is tooled up for manufacture, a range of unit capacities can be provided by supplying several pump wheels with different vane angles which are interchangeable in the basic unit.

Normally, good performance characteristics can be produced over a torque capacity range of just slightly less than 2 : 1 using this method.

The two most important factors influencing capacity are the outlet radius of the impeller, R_1 , and the rotational speed, N . The effect of these two can be seen from the following analysis :

Velocity of fluid flow, V , is proportional to the flow, Q , divided by the flow area, A . Since area is equal to $D \cdot l$ (l being the width of the channel at diameter, D) and the ratio of l to D is always fixed

for similar units. Area, A , can be considered proportional to πD^2 or just D^2 .

$$V :: Q \div D^2$$

Peripheral velocity $U :: ND$ and the ratio of fluid velocity to peripheral velocity must remain a constant. Therefore,

$$\frac{V}{U} = K_1 = \frac{Q/D^2}{ND} \text{ or } Q :: ND^3$$

Head, H , can be expressed as a constant times $V^2/2g$ and since V and U are proportional,

$$H :: \text{Constant} \times \frac{U^2}{2g} :: \frac{N^2 D^2}{2g} :: N^2 D^2$$

Substituting in the abbreviated torque equation

$$T = \frac{kQdH}{N}$$

$$T :: \frac{QH}{N} :: \frac{ND^3 N^2 D^2}{N} :: N^2 D^5 \quad \text{---(13)}$$

Since power $P = Tw$ and $w = \frac{2\pi N}{60} :: N$

$$P :: (N^2 D^5) (N) :: N^3 D^5 \quad \text{---(14)}$$

From this, it can be seen that the torque capacity will vary as the square of the speed or the 5th power of the diameter of the impeller. Power varies as the cube of the speed and fifth power of the diameter. It is, of course, understood that to maintain model similarity, all linear dimensions must be modified in the same proportion as the diameter change. From this consideration, it is quite obvious that chief matching factor will be unit size and the next most important one will be speed.

This means that for a given engine horsepower, the higher the speed of operation, the smaller the converter will have to be to match the engine torque. A given engine speed and horsepower must be matched with the correct converter capacity to produce satisfactory results. Too large a converter will keep the engines lugged down reducing the potential delivered horsepower. Too small a converter will result in considerable operation on the governor overrun again losing horsepower. Once the proper size is selected to nearly match the engine, accurate tailoring can be accomplished by varying the impeller vane setting. Often, slight adjustment of the governed speed of the engine of 50 or so RPM will bring an engine and converter into better match and thereby deliver more useful work.

INPUT CURVE Vs. ENGINE PULLDOWN

Referring again to Figure 12, let us assume that we have a single stage converter which matches the engine governed torque at a point shown on the converter curve. The converter curve shown is the torque absorption curve for the converter impeller at one given speed. Any change in the input speed to the impeller will result in a change in the absorbed torque which varies as the square of the speed change. As the speed ratio of the converter decreases towards stall, the converter will absorb more torque than that at the engine governed speed and the engine will be lugged down to balance the impeller required torque. This process of lugging down will continue until the peak of the converter torque curve is reached. Then, as the output speed is reduced farther towards stall, the converter absorbed torque requirements fall off and the engine will be unloaded until the engine speed returns to governed at the stall point in this example. If the converter torque should drop below that at the match point at stall, this means the engine would be unloaded to some point on the governor overrun curve. Thus, the actual stalled output torque which

equals the input torque times the converter stall torque ratio, would be reduced by the loss in input torque.

To an equipment operator, this means that as the load forces his vehicle closer to stall, instead of the usual heavy lug down to near stall out that would be experienced in a mechanical drive or more moderate lug down with the three stage, he finds the engine speeding up. This type of action meets with varying degrees of acceptance. The operator who is used to working by engine tone has to adapt himself to new sounds. Some engine flywheel inertia effects are lost, which could be transmitted up to the stalled torque capacity of the converter. However, in some applications such as end loaders, it is advantageous to allow the converter to unload the engine at stall which can then produce maximum speed and capacity of engine driven pumps for operating the hydraulic cylinders on the bucket.

SPLIT TORQUE Vs. ENGINE PULLDOWN

In most industrial applications, practice has shown the desirability of some engine pull down as the load increases. One method of producing a gradual

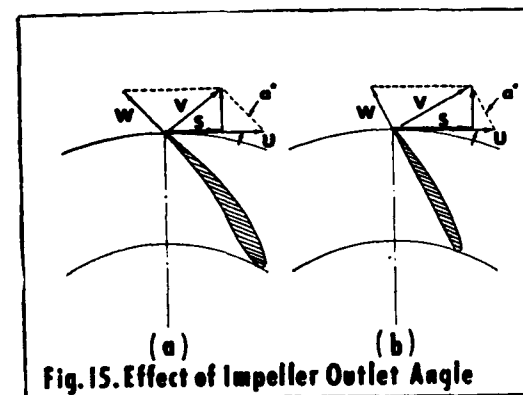


Fig. 15. Effect of Impeller Outlet Angle

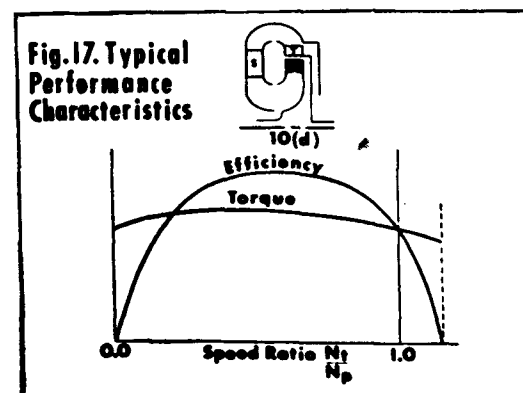


Fig. 17. Typical Performance Characteristics

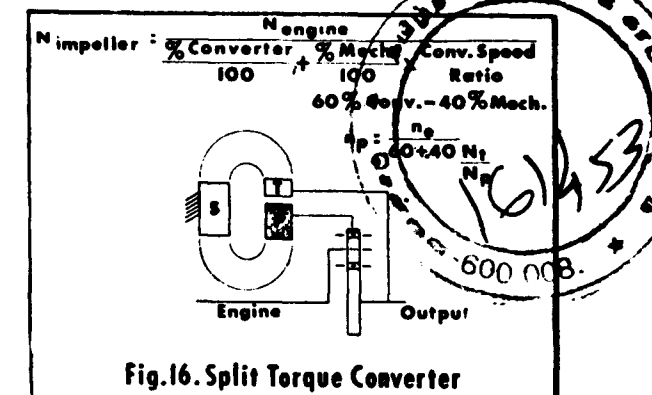


Fig. 16. Split Torque Converter

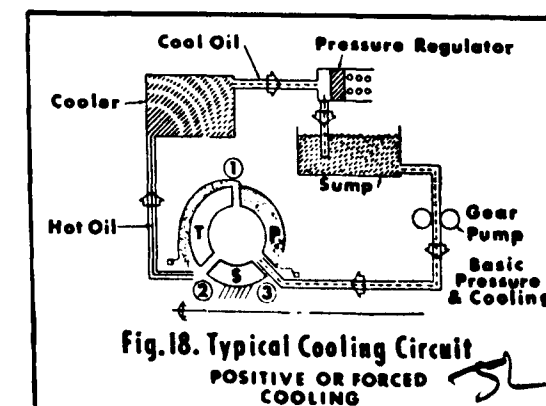


Fig. 18. Typical Cooling Circuit
POSITIVE OR FORCED COOLING

DS153-2, N33
261-7-4

loading of the engine as the speed ratio of the converter is reduced from racing to stall is to modify the relatively flat torque absorption curve of the single stage converter by means of a split torque planetary either ahead of or behind the converter. One possible application is shown in Figure 16. In this example, the engine drives the planet carrier. The ring gear of the planetary drives the torque converter impeller. The turbine is attached to the sun gear and the output shaft. In this system, the engine power is divided into two paths. Part of the power is transmitted through the converter and part mechanically through the gears. Thus, during general operation, the two parts are transmitting simultaneously constantly varying portions of the engine output power. The engine output torque, however, at all times is split up between the converter and mechanical at a definite ratio determined by the gearing. Since only part of the power goes through the converter, only that part is subject to the hydraulic losses of the converter. The remainder going through the mechanical drive passes with normally low gearing losses. The net result is a generally higher efficiency for the system. However, only that part of the torque going to the converter can be multiplied by the torque multiplying ratio of the converter. The torque ratio for the system in the converter torque multiplying range tends to be lower than for the converter alone. Therefore, even though the split system produces high speed ratio ranges of efficiency operation, much higher than the converter alone could produce, the torque output at stall is reduced as is the utility ratio. A successful application of split torque on equipment where wide utility ratio is required depends on using a converter with the widest possible utility ratio to start with and the maximum possible stall torque ratio. Units of this type have been produced and are in operation in Europe at the present time.

Since only a part of the engine power has to be carried by the converter, a smaller converter can be used which could result in lower initial cost if the cost of producing the planetary can be held low enough.

The basic formula for the planetary shown in Figure 16 can be expressed as

$$N_p = \frac{N_e}{\frac{\% \text{ converter}}{100} + \frac{\% \text{ mechanical}}{100}} \times N_t/N_p \quad (15)$$

where N_p = speed of the impeller, RPM
 N_e = speed of the engine, RPM
 N_t/N_p = speed ratio of the converter

From equation (15), it can be seen that, as the converter speed ratio comes down, the total value of the divisor becomes smaller and the speed of the converter impeller rises. It is also evident that the speed of the converter impeller is always faster than the engine speed. Since the impeller absorbed torque goes up by the square of the input speed, the normally "flat" single stage torque curve has been modified in such a manner that it appears to the engine to have a rising characteristic as the output shaft is slowed down by the increasing load. This lugs the engine down at stall in much the same manner as the rising torque curve of the three stage converter.

Combinations of planetary gearing, clutches, and brakes with various converter types are infinite and the study of the resultant engine-converter combined characteristics is a formidable one at best. However, it is one which the manufacturer cannot afford to pass up in his search for the ultimate in performance of his piece of equipment.

HIGH SPEED RATIO CHARACTERISTICS

Referring again to Figure 12, the high speed ratio portion of the torque absorption curve for a typical single stage converter of the type shown in Figure 10(a) shows a gradually falling characteristic due to the flow shut off characteristics of the circuit as the turbine wheel approaches the speed of the impeller. Some converters of this type have freewheeled stators which, in this range, float with fluid rotation. In this phase, the unit is operating as a hydraulic coupling at efficiencies approaching those of couplings. That is the efficiency is equal to the speed ratio. As the speed ratio in the coupling range increases, the falling torque characteristic unloads the engine down the governor overrun curve. In spite of the fact that the converter is operating at high efficiency, very little torque is transmitted due to the rapid loss of torque supplied by the engine.

In most cases, a much less efficient unit than the converter coupling can actually transmit more output horsepower if the converter has a sustained torque absorption characteristic at racing. Circuit 10(c), whose performance is shown in Figure 13, was designed to maintain this torque capacity at higher speed ratios and to prevent the loss of theoretical stalled output torque by actually pulling the engine down slightly at stall due to its rising torque curve. Figure 13 shows the comparison between the characteristics of the outflow stator converter of type 10(b) and the inflow stator of type 10(c).

HIGH UTILITY RATIO SINGLE STAGE

Figure 10(d) shows another type of single stage configuration consisting of an outflow turbine and an inflow stator in addition to the impeller wheel.

This type of converter does not have a flow shut off characteristic because of the outflow turbine and stationary stator, neither of which can produce a counter head to that of the impeller. At the high speed ratio end of the curve, as shown by the performance curve Figure 17, when the unit has zero efficiency at runout, the converter still absorbs torque in much the same manner as the three stage converter. This torque absorption characteristic is not the only unique feature of this particular type of single stage unit. Tests have shown that this converter is capable of producing stall torque ratios up to 7:1 and utility ratios between 3.6 and 4.0:1 and operating at efficiencies up to 86%. This is quite an achievement when it is realized that the normal single stage converter produces stall torque ratios from 2.0:1 to 3:8:1 and without poly-phase operation rarely exceed 2.5:1 in utility ratio. The runout over 1:1 is typical of the higher capacity units in a given size.

FLOW-HEAD RELATIONSHIPS

To better understand the basic differences between these converters and their characteristics, we must return to the generalized torque equation

$$T = kQH \quad (8)$$

This equation shows that two units having the same torque capacity could have quite different flow and head characteristics as long as the products of the two were equal. To evaluate the given specific types of converters covered in this paper, it has been necessary to build or obtain samples of each type and after a complete dynamometer test, calculate their flow characteristics. Using the physical dimensions of vane diameters, vane channel areas, and vane angles, and the performance data, the flow in cu. ft./sec. and the head in ft. were calculated on the basis of design path flow at a common input speed. Naturally, these units varied widely in size and capacity. Therefore, to compare them on a common basis, all units were mathematically corrected to a given input requirement of 1,000 lb. ft. at 1700 RPM at the coupling or 1:1 torque ratio point. This meant that first the impeller diameter necessary to absorb, 1,000 lb. ft. had to be determined on the basis that the torque would be changed by the 5th power of the

impeller outer diameter. Flow then was modified by the cube of the ratio of the 1,000 lb. ft. diameter to the test diameter. Head was modified by the square of this same ratio.

The data obtained from this analysis enabled us to divide the converter types into three definite major groups in terms of head and flow. These groups could be labelled as follows:

Low Flow-High Head	Types 10 (a), 10 (b), 10 (c)
Medium Flow-Medium Head	Type 10 (e)
High Flow-Low Head	Type 10 (d)

The flow in the medium group ran about 66% of that in the high flow group. The low flow group had only 25% as much flow as the high.

It is necessary for the converter designer to consider the amount of flow in a certain type when the method of production is determined. High flow leads to high losses due to viscosity changes in a given fluid operating at low temperatures or in fluids of high viscosity at normal operating temperatures. The surface finish and vane nose contours in the high flow unit must be of excellent quality to minimize the fluid friction losses and the losses due to local separation of fluid from the vane surfaces and resultant energy loss.

Specifically, this means that units of the low flow type, i. e., 10 (a), 10 (b), and 10 (c) can be produced from cast aluminum by sand, plaster, or shell mold methods with their inherently rougher surfaces and can be operated on fairly high viscosity oil such as SAE // 10 and still produce efficiencies between 86 and 90 percent. Substituting a low viscosity fluid, such as kerosene or diesel fuel, in these circuits will not significantly improve their performance.

Medium flow units of the Twin Disc three stage type require surface finishes as good as practical to produce the maximum performance. At the present time, surface finishes of not higher than 125 RMS are specified on all circuit parts. This can be accomplished with good machining practices, fabricated stages of rolled or extruded vane shapes, and stampings.

To realize maximum performance from units of the high flow group, better finishes are required, probably in the range of 60 to 85 RMS acquired by some grinding, polishing, and buffing procedures.

CONVERTER COOLING

One of the major problems of torque converter application is that the power lost in the inefficiency of the converter results in heat. Referring to the performance curve in Figure 5, the efficiency curve represents the percentage of power transmission through the converter. At stall under heavy load, the efficiency is zero, therefore the power of the engine is trapped in the converter and must revert to heat. It is also obvious that under no load with the turbine runout speed determined by the blading, the efficiency is again zero and any power from the engine entering the converter must be transferred into heat.

Form this, it is also obvious that the engine speed at stall and racing, determined by the converter impeller characteristics, will determine the amount of input power and therefore the amount of heat to be handled in a cooling system.

Fortunately, in most earth moving converter applications, it is virtually impossible to stall the converter because of wheel or track slippage. Also extremely low speed ratio operation is only intermittent and overheating very rarely occurs from this source.

However, the other end of the curve is a different story and one which is most often misunderstood by the layman. Under very light load conditions or when using an oversized converter, that is one which matches the engine far to the right, it is possible to be putting in considerable engine power but operating at low efficiency at the high speed ratios.

In Figure 5, assume the converter and full throttle engine governed torque match at 0.75 speed ratio. This occurs at a converter efficiency of 76%, a normal matching point for this type converter. Now assume the load on the wheels or tracks decreases. The turbine RPM rises. The impeller absorbed torque decreases, unloading the engine down the governor overrun curve. Assume the output shaft is completely unloaded, such as would occur if the transmission following the converter was shifted to neutral. At this point, the input torque requirement of the converter equals the drag torque of the stator and the engine reaches its minimum horsepower output on the governor overrun, matching the input and stator torque. Using a converter performance such as that shown in Figure 5, the heat generated under this no load racing condition is usually the governing factor in calculating the cooling capacity requirements for continuous operation. The heat developed during

downhill braking can also dictate the size of cooling capacity.

If the converter torque absorption requirements drop to near zero in this range, either by virtue of hydrodynamic flow shutoff or freewheeling the stator, the cooling requirement under racing conditions will be greatly reduced.

The heat trapped in the converter must be dissipated in a radiator or heat exchanger. In order for this cooling to take place, fluid from the converter circuit must be moved to the cooler and returned to the converter. Here again, the basic design of the converter can make this problem cheap and simple or costly both in initial expense for an adequate pump and in loss of available horsepower to drive the pump.

To demonstrate the basic differences between converter types, we refer to Figure 10. It has been mentioned that one of the so-called "by products" of a rotating centrifugal impeller is pressure. Therefore, if we can tap the converter system providing a path from the higher pressure through the cooler and back to the low pressure side, we can make use of pressure differential to push the cooling oil through the cooling circuit. If we cannot tap a sufficient pressure differential, it is necessary to use a positive displacement pump driven by the engine to do this job.

The converters shown in Figures 10 (a), (b), and (c) are rotating housing converters. That is, one element, either the impeller or the turbine, is attached to a cover which surrounds the other members of the circuit and forms a casing in which the fluid is contained. The rotating casing is then mounted inside a fixed housing mounted to the flywheel housing or the transmission case which acts as a cover for the rotating parts, a sump for the excess oil supply, and as a means of supporting the rotating members.

Ordinarily, piston ring seals are used to seal the fluid in the converter circuit. These rings are usually kept to the minimum possible diameter to reduce friction loss and subsequent wear. Thus, the cooling oil must move radially inwards from the high pressure impeller outer diameter 1, Figure 18, through the space between the cover and the internal wheel, under the sealing rings at 2 to the exit passage provided in the fixed outer housing, and thence to the cooler and back to the inlet side of the impeller 3. The oil in the space 1 to 2 between the internal

wheel and the cover builds up its own counter centrifugal head which reduces the high pressure potential existing at the impeller outlet. The external cooling circuit senses only the pressure differential remaining between points 2 and 3. Generally, this differential is close to zero by the time the fluid has emerged from its rather devious path to the housing mounting pads where the fluid cooling hoses can be attached. Thus, this type converter will normally require an engine driven pump for a positive or forced cooling system.

Assuming that it would be necessary to cool 30% of the engine horsepower under the worst conditions that the converter will be operated in for extended periods of time, and assuming the use of economical heat exchanger design, the cooling requirements would normally be between 10 and 15 GPM per 100 engine horsepower. It is easy to see that this external pump could be quite a sizeable one in some applications.

Figures 10 (d) and 10 (e) show converters of the stationary housing type in which all wheels rotate within the converter housing and in which the stator vanes are attached directly to the housing. In this type of unit, it is possible to tap the housing at almost any desired point (reference Figure 19) and to make use of virtually all the available pressure drop the impeller can provide. Depending on the speed of operation and the physical size of this type of unit, the available cooling flow then depends entirely on the size of the lines and the resultant pipe friction, bend, entrance, and exit losses. A 1" line system with a radiator and 20 odd feet of piping would have flows in the range of 30 to 50 GPM at 20 to 40 PSI differential. This cooling flow bleed from the circuit is a negligible loss when the total output of the centrifugal impeller is considered. A converter with an impeller outlet diameter of about 13 3/4 inches running at 1700 RPM in the Twin Disc three stage converter is circulating fluid at the rate of 8 to 10 cu. ft./sec. within the circuit. This amounts to 3600 to 4500 GPM.

PUSH STARTING

Since the fluid is the only connection between the input shaft and the output shaft in the hydrodynamic transmission, it is often necessary to supply a mechanical lock up for push starting the vehicle. A direct drive clutch between the impeller and the turbine drive shafts can be engaged by means of hydraulic pressure from a gear pump driven from the tracks or wheels. In units which do not normally

have a direct drive clutch, a freewheel is installed between the impeller shaft and the turbine shaft. This freewheel operates at differential speeds during the normal working cycle from zero speed ratio to 1.0 speed ratio. The freewheel locks up when the turbine reaches impeller speed, thus preventing the converter from operating over 1:1 speed ratio. Here also the resultant performance varies with the converter design characteristics.

Figure 20 (a) shows the efficiency and torque absorbing characteristics of a high runout converter with sustained torque characteristics. Without the freewheel, the turbine at 1:1 speed ratio still has potential output torque. The freewheel prevents the turbine from attaining zero torque output over 1:0:1 and the excess torque over that required to operate at 1:1 returns through the freewheel to the impeller. Since the impeller can only absorb a given amount of torque at a given speed, the torque supplied by the turbine reduces that required of the engine and the engine is unloaded further down the overrun curve. Under no output shaft load conditions,

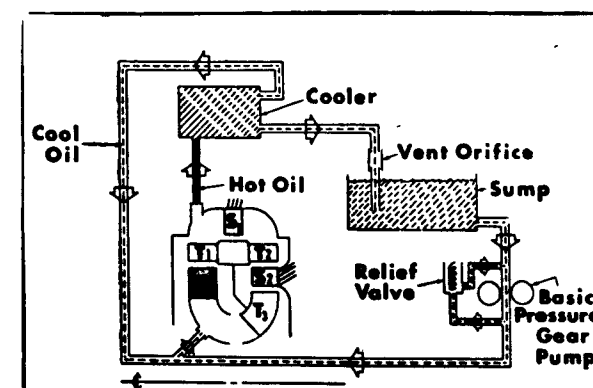


Fig. 19. Typical Cooling Circuit-Natural Cooling

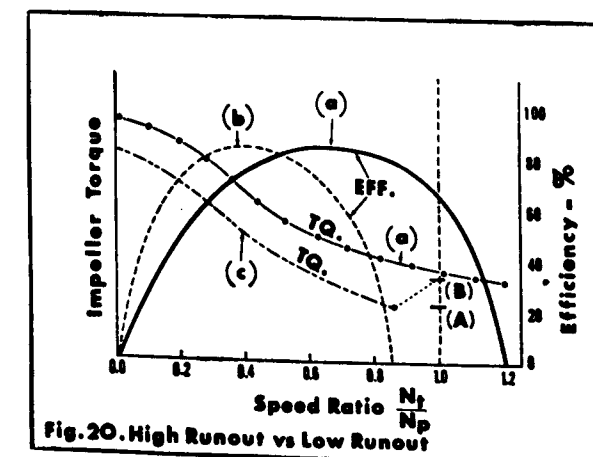


Fig. 20. High Runout vs Low Runout

the engine speed will rise until the engine output matches the stator torque.

The power absorbed by the stators and supplied by the engine is determined by the inefficiency of the converter at the 1:1 speed ratio point. Thus, the more efficient the converter at 1:1, the less cooling will be required.

Figure 20 (b) represents a converter with sustained torque requirements, but which runs out under 1:1 S. R. In this case, even though the unit contains a push start freewheel, it can never engage the freewheel under its own power. Thus, the impeller torque at runout determines the output torque of the engine and also the cooling requirement. A push start freewheel in a rotating housing type converter whose shutoff condition occurs at or prior to 1:1 will not affect the heat problem as the engine is more or less completely unloaded.

CRANKING CHARACTERISTICS

Periodically, the question comes up of the cranking characteristics of different converter types without a direct lockup clutch or a push start freewheel.

A torque converter can be run in the Lab by driving the turbine and measuring the torque delivered at the impeller shaft at different speeds. Under these operating conditions, the fluid in the circuit is at ambient temperature, seldom lower than 70° unless a special cold room is provided. The fluid is in a fairly thin state compared to normal push start operations at temperatures well below zero. These conditions will produce torque transmitting flow characteristics and the unit designed as the best hydraulic coupling will theoretically give the greatest cranking torque.

Several factors in actual practice tend to affect the actual cranking torque during the cold start.

Units of the rotating housing type normally drain down to somewhat less than half full after a shutdown because of the piston ring seals. The full cranking potential then will not be realized until the cold thick oil is forced into the converter and a flow pattern set up.

Converter cranking requires comparatively high ground speed which would depend on the footing for and capacity of the pushing vehicle.

Successful field push starts have been accomplished

with converter types that theoretically have poor push start characteristics. This was probably due to a shearing action in the thick cold oil rather than a fluid flow condition.

The general conclusion that seems indicated is that push start cranking with a converter only is uncertain at best. For positive cranking at lower ground speed, a freewheel or lockup clutch is more dependable.

BRAKING CHARACTERISTICS

Many vehicle applications require braking for certain operating conditions. Braking occurs at a high speed ratio when the turbine wheel is being driven by the tracks or wheels and the power supply is coming from the inertia of the vehicle and load. If a push to start freewheel is used, part of the braking is supplied by the engine compression. If the converter is the rotating housing, shutoff type, it can supply little or no braking effort. This requires the use of an auxiliary hydrokinetic brake, which consists of an impeller attached to the output shaft and fixed vanes attached to the vehicle frame through a housing and is in essence a stalled hydraulic coupling. In the normal working range, this coupling must be dumped to prevent power loss. If the converter is the sustained torque type with fixed stator vanes, the flow of oil against the stator vanes will supply an additional braking force equal to the ability of the vanes to absorb torque which varies about as the square of the speed. The braking ability of any converter at 1:1 is closely allied, therefore, with the heat characteristics discussed under cooling. Figure 20 showed that in a high runout converter, the higher the efficiency at 1:1, the lower the heat load. Similarly, the higher the efficiency, the lower the stator torque and therefore the lower the braking.

The regenerative feature of the high runout turbine wheel in unit 20(a) sends part of its power to the impeller wheel which reduces the net braking effect.

Unit 20(b), which has a runout under 1:1, would provide more braking than unit 20(a), since it requires external effort from the wheels to drive the turbine wheel up to 1:1 lockup.

For example, a high runout unit of the three stage Twin Disc type converter with a 13½" impeller and a push to start freewheel could supply 290 lb. ft. braking torque at 1700 RPM output shaft speed in a unit whose match point torque would be 390 lb. ft. at 1700 impeller RPM. A similar low runout unit would have a braking torque of 330 lb. ft. at 1700 RPM with a

match point capacity of 200 lb. ft. at 1700 impeller RPM.

When converter braking of this type unit is combined with the engine braking, no auxiliary hydrokinetic brake type of device is normally required.

The performance characteristics that have just been discussed are some of the major ones that must be taken into account in the evaluation of equipment performance and design. When the hydraulic torque converter is understood and used to its maximum degree, its use can offer some tremendous advantages to the ultimate user. In order to recognize its maximum utility, it must be designed as an integral part of the power train. An educated, planned approach to its use can influence the choice of engine characteristics, the number of gear shifts, and the reduction ratio of the mechanical portion of the drive train.

MACHINE TO TRIM DRAWN METAL STAMPINGS OF IRREGULAR SHAPE

A new machine for trimming drawn metal stampings of irregular shape has been produced by a U. K. firm.

Trimming tools, shaped to suit the component, are mounted on four reciprocating slides which run in strong guideways fitted with adjustable gibs. The slides are arranged in two sets of opposite pairs, the entire mechanism being cam controlled. The actual trimming operation takes only a fraction of a second for each component, apart from the time required for manual loading and unloading of the components.

In operation, the component is placed over a tool block which is a close fit in the interior of the component, the bottom ledge of the block forming one of the trimming cutting edges. The component is clamped by a pneumatic chuck whose controls are also part of the safety system, as they ensure that the operator's hands are out of reach of the trimming tools before these can be actuated.

The trimming action is initiated by a treadle which engages a non-repeating key clutch and thus operates the camshaft which in turn engages two slides in succession, each slide pair being located diametrically opposite the other pair. Mutual jamming of the slides is thus impossible. The trimmed component is raised by ejector pads in the tool block to facilitate unloading and the trimmed scrap is cut and removed by

The converter types discussed here are by no means the final answer to the torque converter design problem. Future developments in industrial equipment will include the combination of converters and planetaries which are capable of modifying converter characteristics in many different ways.

The converter will continue to play an integral role in the development and use of the power shift transmission, as the heavier earth moving vehicles continue on their design path towards ease of handling that rivals that of the passenger car.

In keeping step with this revolutionary phase of development, it is the duty of the engineer to produce a proper marriage of the converters that can be different to the jobs that are different.

the continuously operating scrap cutter and removal hook.

* * * * *

A BRITISH FIRM'S BIG MANUFACTURING VENTURE IN NIGERIA

Plans to build two plants in Western Nigeria, involving a capital investment of approximately £500,000 has been announced by Imperial Chemical Industries Ltd. They are to manufacture paints and plant protection products.

The paints factory will manufacture the firm's 'Dulux' and 'Pentalite' ranges of paints. It will be designed so that the output can be expanded and the range of products extended to meet the country's rising standard of living.

A plant to manufacture and pack products of the I.C.I. subsidiary company, Plant Protection Ltd. of importance to the cocoa industry will operate on the same site. These will include 'Gammalin' 20 for capsid control and 'Perenox' to prevent black pod disease.

This will be I.C.I.'s first manufacturing venture in Nigeria, where I.C.I. (Export) Ltd. was recently established as a merchandising organisation. I.C.I. (Export) will act as the managing agents for the new project.

Modernity in Crankshaft Manufacture

Report on a Visit to the Ambrose Shardlow Establishment

FOR producing crankshafts by flow production methods for automobile and industrial engines, Ambrose Shardlow and Co., Ltd., Earling Works, Meadowhall, Sheffield, have a personnel of approximately 1,500, manufacturing upwards of 10,000 drop-forged crankshafts and 10,000 fully machined crankshafts per week.

The factory is claimed to be one of the best equipped in Europe for producing either drop forgings or fully machined shafts, according to customers' requirements. They include many of the main automobile and commercial vehicle manufacturers, also leading makers of oil engines in Great Britain and numerous concerns abroad. Crankshafts manufactured vary from 2½ ft. to 10½ ft. in length, and from one-throw to an eight-throw shaft.

STILL GREATER CAPACITY

It is the concern's intention to increase the range of their crankshaft machining capacity to include shafts up to an overall length of 20 ft. Towards this end, after full world-wide investigation of the latest production methods for this type of shaft, they are proposing to install the necessary plant and adopt techniques which will enable them to compete successfully in this market in the near future.

During our recent visit to the Ealing Works we were impressed by the "know-how" employed in the various departments throughout the works. We now give a few particulars of some of the methods and machines inspected during the visit.

The drop forge shop consisted of three bays with oil- and gas-burning furnaces, and 20 hammers of various types ranging from 1½ tons to 18 tons; 70% of the hammers are of British manufacture and the remainder of American and German makes. In the production of crankshafts full use is made of dies.

One of the latest forges is provided with two Beche double-acting hammers for billets up to 33 in. On these hammers all the work is done in one "heat," and this includes rolling, bending and finishing all in 1½ min., and in one die. Small shafts can be made by the three-machine method—two being hammers and

one a press. The process consists of preparation, stamping, trimming, setting and finishing. Another method of making an oil engine crankshaft from a 33-in. billet, comprises its first being stamped out flat, the flash removed. The pins are then twisted into position by an hydraulic twisting machine, then given a final blow to set the shaft.

All dies are designed and made at the Ealing Works. They have an important influence on all the forging operations because it affects both the cost of manufacture and the quality of the product. Matching of the dies is automatic, employing the profile system and all dies are hand finished. Some dies are designed to roll, bend and finish stamp the billets, others just roll and bend, or prepare, or finish stamp, depending upon the style of shaft and quantities in production. A lead proof is made of each die to ensure that both halves match up. For small quantity crankshaft production when the cost of dies is uneconomical the shaft is forged by means of hand-operated tools under a power hammer.

The die shop is located away from the forge to eliminate vibration from heavy hammer operation. It is fully equipped for the manufacture of any pattern of die required. Amongst the machines installed are Cincinnati, Hiloplane and Hydrotels and four Keller die-sinking machines. Die blocks vary in weight from about 15 cwt. up to 4 tons. It is claimed that a Shardlow die seldom breaks or cracks in service, proving the care that is taken in its design and making.

Included in the machine division are the drawing office, planning department, machine shop, induction and nitride hardening sections, balancing, lapping and finishing sections, jig and tool shop, and the instrument and gauge section. In the machine shop there are a number of special-purpose machines designed and made by Shardlow to suit particular types of crankshaft. The main shop is 430 ft. long by 390 ft. wide, divided into 13 longitudinal bays.

For crankshafts for four- and six-cylinder engines there are between 30 and 50 machining operations. Shafts hardened by nitriding process take more machining than those which are induction hardened. For a particular six-throw crankshaft the machining



CRANKSHAFTS

FORGED

AMBROSE SHARDLOW & CO. LTD.

P.O. BOX 129 - MEADOW HALL

SHEFFIELD

Telephone : ROTHERHAM 4691

operations are carried out on three vertical lathes which form a unit. The first machine does the outer pins, the second the two intermediate pins and the third machine the centre pins.

SPECIAL-PURPOSE PLANT

Another example is a Le Blond lathe which can turn six crankpins of a special type of crankshaft at one operation. A Drummond Maximatic centre-drive lathe accommodate two crankshafts at the same time. It turns all the main journals, web faces, web bevels, timing wheel diameter and flange diameters. Drilling of the oil galleries and holes is done on a six-spindle Farmer automatic drilling machine. The feed is hydraulic and the drills are electrically controlled by means of a time relay. Each spindle is set to drill to a given depth and the drill then withdraws. Also if, for any reason, the drilling torque exceeds the pre-set figure the drill will withdraw. These are only a few of the special machines.

In the heat-treatment department there is a battery of Gibbons furnaces. Forgings are placed in automatic chargers before entering the furnaces. Induction hardening takes place after rough grinding of the

crankshaft. A special bay is set aside for this purpose, one section for large quantity production and another section for smaller quantities. A semi-automatic plant provides, where necessary, facilities for hardening the surfaces of the shafts. Nitride hardening takes place in another bay where there are ample equipment items for this process. About 70% of the shafts are induction hardened.

Dynamic, static balancing and super finishing are achieved by means of the latest types of machine, resulting in finished crankshafts up to the highest standards of accuracy and micro finish. Both drop-forged and fully machined crankshafts are submitted to rigid inspection prior to dispatch; the inspection facilities have been approved by the Ministry of Supply, Lloyd's Register of Shipping, Ministry of Transport and the Air Registration Board.

The tool room, also the chemical and physical laboratory, play a big part in the production of the crankshafts. All are well equipped with modern plant and apparatus to ensure that the crankshafts are produced economically during the forging and machining processes, and that the materials used are up to standard.

WESTERN RAILWAY BOMBAY—DELHI BI-WEEKLY AIR CONDITIONED EXPRESS TRAIN EXTENDED TO AMRITSAR ONCE A WEEK

The Bi-weekly Air-conditioned Express running at present between Bombay Central and New Delhi has been extended to run to and from Amritsar once a week.

The extended service to and from Amritsar started operating from Bombay Central from Wednesday, 21st June, 1961 and from Amritsar from Friday, 23rd June, 1961. The extended service is being run every Wednesday from Bombay Central and every Friday from Amritsar. These trains run to the usual timings between Bombay Central and New Delhi. The train from Bombay arriving New Delhi at 10.20 hours leaves New Delhi at 11.20 hours and arrives Amritsar at 19.35 hours. The train from Amritsar departs at 06.00 hours, arrives New Delhi at 14.45 hours and departs at 16.10 hours for Bombay.

The air-conditioned Express leaving Bombay Central on Sundays and New Delhi on Mondays, continues to run between Bombay Central and New Delhi as at present.

LOCKERS AT WESTERN RAILWAY STATIONS

As an amenity to railway passengers who desire to keep their valuables in a safe place while travelling, Safe Deposit Lockers have been provided by the Western Railway at Bombay Central, Ahmedabad, Jaipur and Agra Fort station. For use of these lockers a small charge of 50 nP. per locker per day or part of a day is levied subject to a minimum charge of Re. 1. A deposit of Rs. 5 which is required to be paid in advance is refunded when the locker is released.

Each locker, which is big enough to accommodate a small suitcase, is allotted for a maximum period of one week to any passenger who is required to sign a "deed of license" for the purpose. Articles of dangerous, explosive, offensive or perishable nature are not permitted to be kept inside the locker.

Further particulars can be obtained from the Station Superintendents and station Masters concerned.

To ensure faultless operation of your rectifier sub-stations



Do you want the guarantee, that your installation can be switched on without preheating, even at extremely low temperatures, and that the toughest overloads and short-circuits will not damage your equipment? Then choose Sécheron-built mercury-arc rectifiers, with their rare gas filling, sealed tank and air cooling.

● Sécheron Rectifiers Symbol of quality and security

Other Sécheron products:
Electric equipment for traction vehicles,
Generators, transformers, regulators,
Electrodes and arc-welding material.

Sécheron Works Co, Ltd. Geneva 21, Switzerland

L 110 a

Representatives for India:-
M/s. Industrial & Engineering Combine
Post Box No. 1323, BOMBAY

THE RELATIVE MERITS OF DIESEL AND ELECTRIC TRACTION AND THE PROBLEMS OF CHANGE OVER — A PHASE OF THE RAILWAY TRACTION DEVELOPMENT

By *Dott. Ing. Leone Ravenna*

of Ercole Marelli & C. S.p.A Milan - Italy

DIESEL Traction was born in Europe—the first Diesel Engine application on rail-vehicles appeared in France in the first years of the 20th century—but developed in America, United States.

During the last years, however, a remarkable impulse in this branch arose also in Europe: something did move, and new solutions were offered by new manufacturers to new buyers.

Birth and affirmation of Diesel locomotive were due to a definite exigence, when it was remarked the determining influence the kind of the employed motive power has on the railway operating total expense.

The most proper choice of the locomotive type was taken then in the greatest consideration: a locomotive is to be regarded as an instrument, but, more-

various, but, above all, the initial cost of plans as transmission and distribution lines, substations and overhead system, has always been the main obstacle for new electrifications. Therefore, speaking of new electrifications, the decisive factor has always been the traffic records.



Electric locomotives for Italian State Railways

- wheel arrangement Bo-Bo
- Weight in working order 72 metric tons
- 1 hour rating 1560 kW
- maximum speed 70 mph

Electric parts by Marelli - Milan

Mechanical parts by Reggiane-Reggio Emilia

Except special cases, as profiles of line on which the tonnage has to be handled (mountains), and conditions of power supply (large water resources and fault of coal for steam locomotives or of fuel for Diesel engines)—i. e. Switzerland—electrification is not a good business when ton-miles to be handled are under a definite limit.

Really electrification means a new expense for plants to save an operating expense, and other items are to be considered besides the handled traffic and the line potentiality: the cost of transformation (locomotives, substations including switching, trolley catenary system and bonding, transmission signal and communications circuit changes, and so on) and the operating cost with steam, diesel and electric locomotives (locomotive maintenance, locomotive deprecia-



Motor Coach for Italian State Railways

- 1 hour rating 368 kW

- maximum speed 80 mph

Electric parts by Marelli - Milan

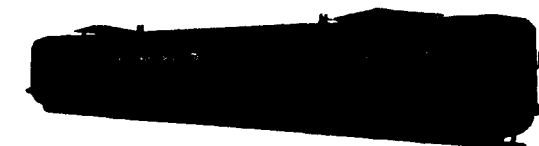
Mechanical parts by Fiat - Turin

over, is to be valued on economical terms, from the standpoints of the purchase expenses and of the yearly operating cost.

Stating beforehand that the comparison is specially done between dieselisation and electrification, since steam traction is not suited to the 20th century, the factors affecting the change of motive power are

Marelli

THE MOST IMPORTANT REALISATIONS
IN THE RAILWAYS BRANCH



*Electric Motorcoach ALe 79 - Italian State Railways -
3,000v D.C. - 370 kW - 81 mph - year 1937*



*Double Electric Motorcoach - Soc. Nationale des Chemins de
Fer Belges - 3,000v D.C. - 880 kW - 75 mph - year 1950*

ERCOLE MARELLI & C. - S.p.A. - MILANO

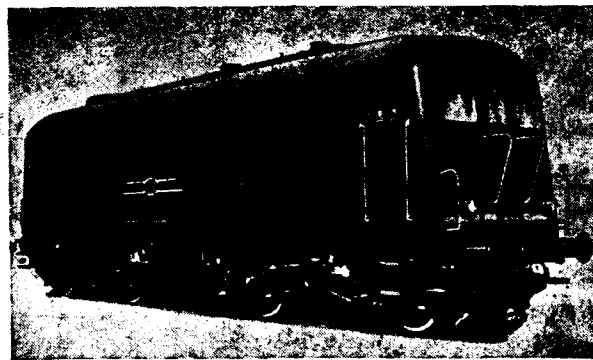
tion, crew expense, engine house expense, cost of electrical energy, distribution system and substations maintenance, distribution system and substations depreciation, and so on).

The difference between operating cost with new and old system, should, at least, equal the yearly charges.

Practically all the most important railways that are electrified at present, began with steam operation.



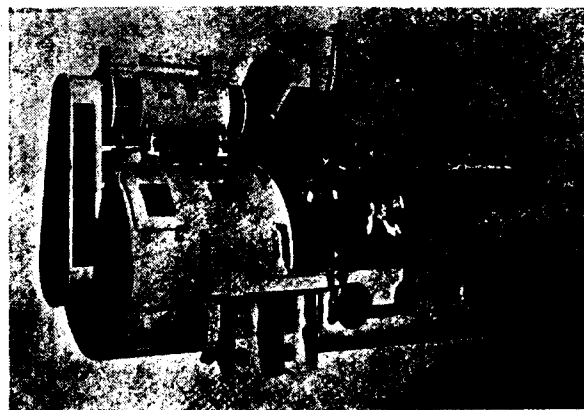
Electric locomotives for Italian State Railways
- wheel arrangement Bo + Bo + Bo
- weight in working order 108 metric tons
- 1 hour rating 4000 kW
- maximum speed 90 mph
Electric parts by Marelli - Milan
Mechanical parts by OM - Milan



Diesel Electric locomotives for Italian South East Railways
- wheel arrangement Bo-Bo
- weight in working order 52 metric tons
- continuous rating 825 HP
- maximum speed 50 mph
Electric parts by Marelli - Milan
Thermal parts by Reggiane - Reggio Emilia
Mechanical parts by Reggiane - Reggio Emilia

Then, at a given moment, substitution of steam traction by an other system thrust itself upon, to face new or simply increased exploitation exigences and they passed to the Diesel or even to the electric traction, but always on the basis of the so-called "convenience limit": a limit that is reached as faster as lower is the expense for new plants, as higher are the traffic records and, obviously, as remarkable is the difference between new and old operating cost.

Of course, such "convenience limit" cannot be established as absolute and general value, but it depends from number of elements that are characteristic of different countries and that can influence choice between dieselisation and electrification, when steam traction will obsolete. Then, normally, the specific solution of the one region's problems is not necessary applicable in another place.



Diesel-generator set for Diesel electric locomotive
- continuous rating 25 HP at 1300 rpm
- total weight with auxiliary set 6900 Kg
Engine built by Reggiane-License Man
Electric generators built by Marelli - Milan

As always, the reasons of such differences are partly technical and partly economical: take, i. e., USA and Europe's situations.

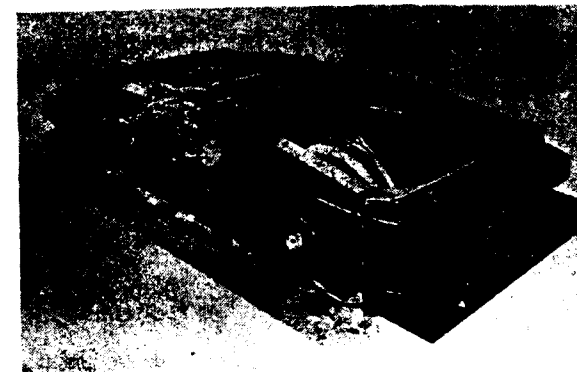
A first problem's side concerns motive agents: electrification allows to employ a large range of fuel qualities: firstly, hydraulic energy, then, more or less select masut methane, coal; on the contrary, Diesel locomotive operation is joined to the use of select fuel.

Electrification is really a sort of insurance, when available sources of such fuel are limited in quantity or in time.

In Europe we found lacking masut, coal only in few regions, large hydraulic resources, and there electrification appeared as surety against every supply's uncertainty with railways motive agent and against its high prices. On the contrary, in USA they have plentiful and cheap masut, with assured production in every world politics emergency, and Diesel traction has practically stopped for several years whatever development of a real electrification.

A second problem's side is concerning the different traffic exigences, versus the ambient: crowded populated countries, with high records of traffic on short distances, lines run by frequent and relatively light trains, with high ton-miles standards and consequently somewhat limited incidence of the fixed plants investment, as in Europe, push forward electrification.

Long lines through poor uninhabited territories with relatively few heavy trains made till now in USA the balance slope in favour of Diesel traction: in fact, the Diesel locomotive cost, both as initial expense and as



Bogie with traction motors and reduction gear for Diesel Electric locomotive
- total weight 10300 Kg
- continuous rating for motor 160 HP at 508 rpm
Electric parts by Marelli - Milan
Mechanical parts by Reggiane - Reggio Emilia

maintenance, becomes of less importance when the locomotives per line-mile are relatively few, while the incidence of electric energy production, transmission, transformation and eventual conversion is high.

The third problem's side is given by the difference between financial structures of European and North-American railways: the main European railways are State Railways, the American are private Companies: now, European railways are in a better position for

new electrifications, because of the more important investments they require in comparison with dieselisation: capital outlays, with consequent passive charges, taxes, debt redemption shares and so on, are easier to be supported by European than by North American Railways Companies.

The establishment of the Diesel locomotive in North America is closely related to the rise in the cost of coal due to prolonged pressure from the Unions in the mines.

The difficulty of running railways equipped for the most part with steam locomotives, gave an incentive to the rapid development of the diesel traction engine as a practical system with distinct immediate advantages.



Traction motor for Diesel Electric locomotive
- continuous rating 160 HP at 508 rpm
- total weight, gear box and pinion included: 1660Kg
Builder: Marelli - Milan

The Diesel engine, with electric transmission, reached the realisation of a locomotive capable of developing constant power at wheels between minimum and maximum running speed, with a smooth running of all characteristic tractive effort/speed allowing for longer trains, and the stricter keeping of time-tables with consequent economy of operating costs. In general these are the precise qualities of the electric locomotives, but electrification would have involved permanent installations of great extent, whereas the Diesel locomotive could be constructed in a relatively short time and be put into service without any extensive modification of existing plants.

Thus it was that, until some years ago, in North America some 2000 electric Diesel locomotives were

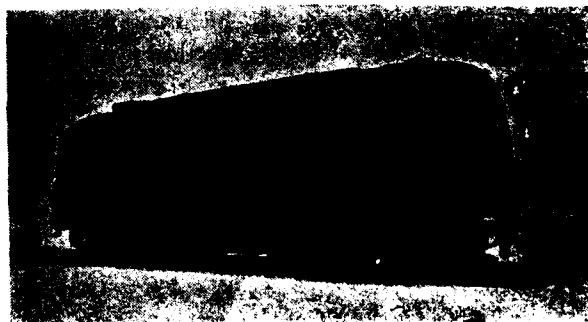
produced annually and at the beginning of 1954, in the United States and Canada alone, more than 24,000 locomotives of this type were on the rails, whilst in the whole of Europe. Gt. Britain—Ireland included, in a total of 74,000 locomotives, there were no more than 900 Diesel, inclusive of the small switchers.

Also in Europe, however, within the last few years this problem of the Diesel locomotives has been looked at from a broader point of view, and European industry has embarked upon an extensive study

same phases of development which has taken place in Europe and the United States of America: from North to South Africa, from the Middle East to Indonesia and from South America to Australia (not to mention Russia, where at the beginning of 1960 the length of lines served by Diesel locomotives had risen by 150% in comparison with that of 1955 and it is expected that this will be five times surpassed by 1965), they are turning over from steam traction (or passing over this completely) to diesel traction, and, when reached the mentioned "limit of convenience", over to electrification.

Immense countries, and continents rich in natural resources and with a continually rising technical potential, are destined to make their needs felt.

In fact, these needs, in the field of plants, appear, for the moment at least, to resemble those of Europe



Diesel Electric locomotive for Italian State Railways
- Wheel arrangement Bo-Bo
- weight in working order 64 metric tons
- continuous rating 1120 HP
- maximum speed 63 mph



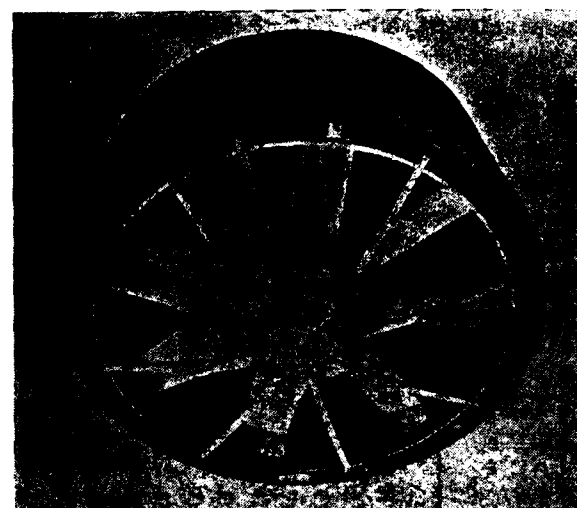
Main generator for Diesel Electric locomotive
- continuous rating 770 kW at 960 rpm
- weight with auxiliary services alternator 6600 Kg
Builder: Marelli - Milan

Electric fan for Diesel Electric locomotive traction motors
- 3180 cu / ft per / minute - 5"
- DC motor at 2300 rpm
Builder: Marelli - Milan

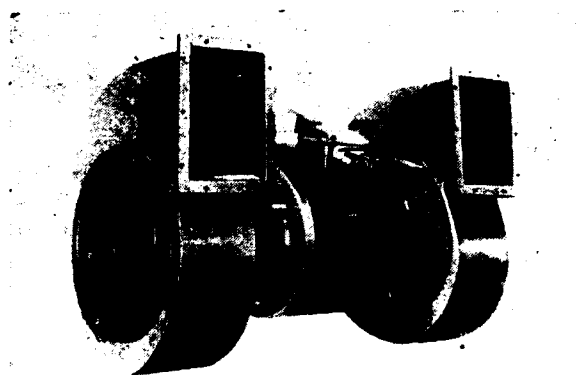
programme of research into the determination and classification of fundamental Diesel and Diesel electric locomotives, to clarify the needs and projects of constructors, and the demands of the different European Railways.

In recent years, moreover, the problems of the railways are not a subject of lively interest only in North America and Europe, but in the whole world; a great number of other countries are undergoing the

more than North America. The North American railways have at their disposal an armament suitable for a load of 30 tons per axle; this is too much if one wishes to use the Diesel on existing lines without wasting time on re-inforcing the tracks:—progress has not to wait! Herein has the similarity just mentioned, i. e. the need for lightness: light locomotives for the new Dieselisation.



Electric fan for Diesel Electric locomotive engine
- 48000 cu/ft-2" with AC induction motor at 1390 rpm
Builder: Marelli - Milan



Electric fan for Diesel Electric locomotive traction motors
- 2700 cu/ft - 7" with AC induction motor at 2820 rpm
Builder: Marelli - Milan

The technical progress in the industry of the high speed Diesel engine, the development in constructing welded steel bogies, and frames of the locomotive, the use of light alloy metals of high specific resistance, which have been highly developed in European

industries to answer the needs of each one of their countries, correspond perfectly to the needs of many parts of Asia, Africa and South America where new techniques can be rapidly assimilated and new constructions norms realised.

The Diesel has become of prime importance throughout the whole world, and the exigences which become each day more pressing (reduction in weight and sizes, increase in power) involve higher revolution speed, supercharging, internal cooling of the pistons.

The technique of various systems of transmission: hydraulic and electric, and the various types of mechanical transmission, is in constant evolution and making rapid progress in a way which renders it impossible to foresee which system will eventually predominate. One cannot expect the same progress and numerous innovations, however, in the field of electrical transmission, as in that of mechanical and hydraulic.



Cubicle for Electric Control Apparatus of 825 HP Diesel Electric locomotive
Builder: Marelli - Milan

Electrical transmission was already in a highly satisfactory state when the first hydraulic system was patented and it has never ceased to improve, while hydraulic systems have often proved laboursome in the perfecting of them.

The constant tendency to lightness is evident even in the transmission as in the Diesel engine—between two locomotives, one of 600 hp. produced in 1945, and the other of 800 hp. produced 10 years later, the gain in weight reached 35% in favour of the second.

Points to notice in the field of electrical transmission: the auxiliary generator, traditionally fitted on the main set shaft, is belt driven in order to use a higher speed machine; the mechanical connection between engine and auxiliary services is more and more employed and the auxiliary generator is subsequently reduced in importance, no longer feeding the separate fans of the traction motors, the compressors, etc., whilst the radiator fans are driven by hydraulic or electric couplings from the end of the Diesel shaft.

Same tendency to electric traction motors at higher speeds, connected to the axles by way of cardanic rods, with a view to reducing considerably the weight of the locomotives, has had little result, because the system becomes thereby more complicated.

With regard to the systems of regulation, these all tend to permit a more efficient utilisation of the whole power of the Diesel without ever overloading.

The control device, therefore, must regulate, at a constant rate, the power which the Diesel develops for each of its running speeds, by means of the electric parameters of the main generator (voltage and current) acting through the excitation of the generator itself, in order to vary the mechanical parameters of the locomotive (tractive effort and speed) continuously and accordingly to the conditions of load, or to gradient.

These modern Diesel electric locomotives: reduced weight per axle (thanks to the constructive characteristics of the mechanical parts and to high speed and supercharged engines); electric transmission studied in its entirety (whether as traction generator and motors or auxiliary services); perfected control systems; minimum maintenance demands; adaptation to every service requirement, whether on main line services or as goods trains, or (for small powered or medium powered types) as switching

service—have been produced and run regularly. Moreover they have been submitted to tests of comparison with similar locomotives, (similar except in transmission which is hydraulic) and have proved a saving and, with equal performances at wheels, less consumption of fuel.

In most parts of the world, today is the day of the Diesel; almost every day a steam locomotive gives way to a Diesel, or, more precisely, a Diesel takes the place of two or three steam locomotive (according to its use) However, ultimately, this is but a phase in the development of the Railway, which must constantly search for more simple and more economic means, if it is not to be submerged by the competition of the other means of transport.

With which, one returns to the question of electrification: as already mentioned, the cost of equipping for Diesel rises sharply in relation to power, owing to the impositions given by gauge and clearance limits, and by admissible axle load, and when heavy trains are to be pulled, the cost of change over to Diesel traction approaches that for electrification, without taking into consideration the fact that, as regards electrification in comparison with the Diesel, in such case the saving on maintenance and energy is considerable, and can completely out-balance the other advantages.

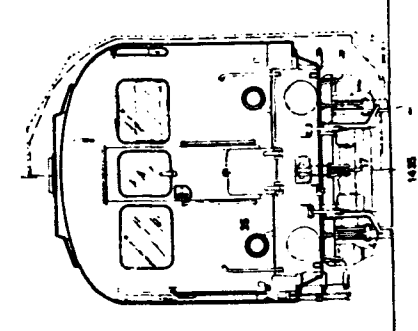
Under these circumstances, electrification becomes more practical than the Diesel: the questions of density of traffic and tonnage become determining factors between the two systems.

On the ever increasing distribution of electricity throughout the whole world and the extension of great interwoven networks, we cannot ignore the fact that owing to many more powers stations of all types, even atomic, put into use, the cost of electricity will constantly be reduced, and this renders electrification easier.

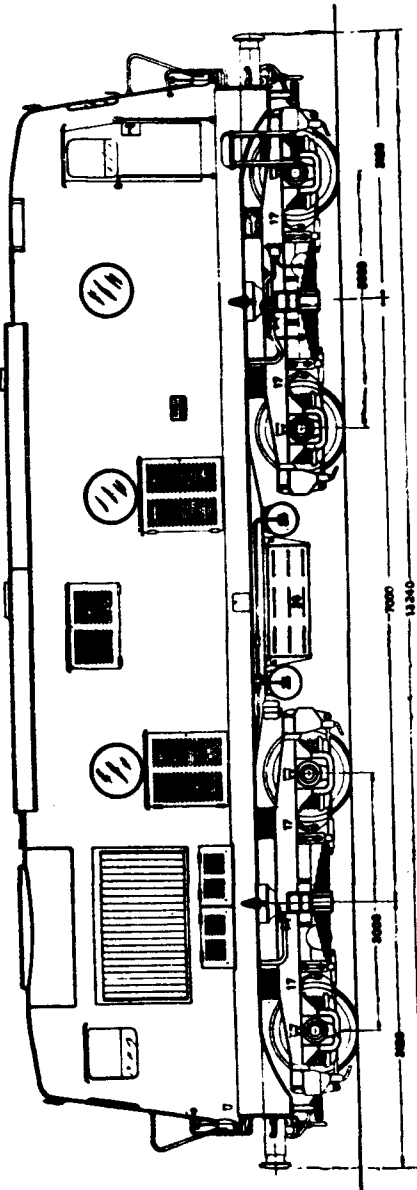
Each electrified kilometer consequently decreases in cost and also the above-mentioned "limit of convenience" steps down—the Railway can therefore face the constant competition of other means of transport.

Which will eventually be the prevailing system of electrification cannot be said for certain: direct or alternate current?

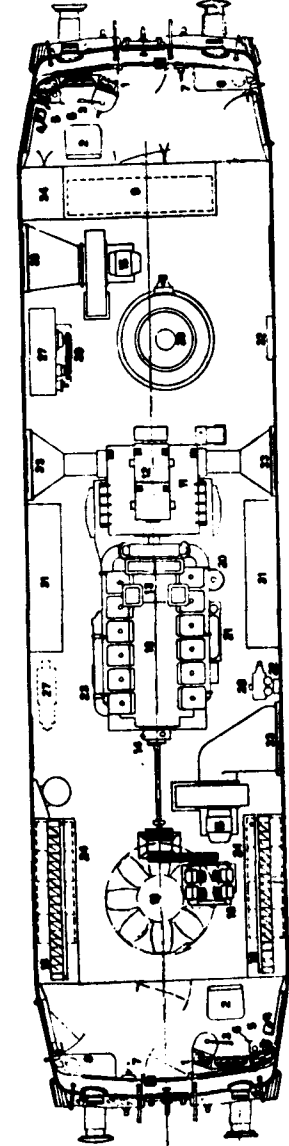
One hears much of the latter and of the highly attractive possibilities of single phase industrial frequency traction, which gives added incentive to the



- 28. Fuel oil pump
- 29. Train-heating boiler
- 30. Train-heating boiler pump
- 31. Train-heating water tank
- 32. Train-heating control panel
- 33. Traction motor and main generator air filters
- 34. Service cupboard
- 35. Headlight



- 1. Operator's controls
- 2. Seats
- 3. Master controller
- 4. Independent brake valve
- 5. Automatic brake valve
- 6. Sander foot push button
- 7. Handbrake
- 8. Fire extinguishers
- 9. Equipment cabinet



- LOCATION OF PRINCIPAL PARTS
- 10. Diesel engine
 - 11. Main generator
 - 12. Auxiliary generator and exciter
 - 13. Turbocharger
 - 14. Woodward governor
 - 15. Traction motor electric blowers
 - 16. Air compressor
 - 17. Traction motors
 - 18. Water radiators
 - 19. Radiator fan
 - 20. Prelube oil pump
 - 21. Lube oil filters
 - 22. Fuel oil filters
 - 23. Heat exchanger
 - 24. Batteries
 - 25. Air reservoirs
 - 26. Fuel oil tank
 - 27. Diesel engine pre-heating boiler

idea of electrifying railways the world over. Certainly, the progress already attained is considerable but not all the difficulties have yet been overcome: rather, they have been overcome thanks to the aid of direct current, with rectifying on vehicles. But are these vehicles D. C. or A. C. locomotives? And how many are the savings with one substation per vehicle?

Thus the question here lies not so much in the technical field, as in terms of actual cost. An exact assessment of the situation, moreover, is difficult to come by, for all reports come from different parts of the world with greatly differing economic conditions.

AEI PLANT FOR FORD'S MERSEYSIDE FACTORY

Ford Motor Company Ltd., has specified that all electric motors for their new Factory at Halewood, on Merseyside, are to be made by Associated Electrical Industries Ltd.

Orders obtained by AEI for this factory total £167,000. They include electric motors from $\frac{1}{2}$ h. p. to 850 h. p. to be supplied by both AEI Motor and Control Gear and Heavy Plant Divisions; and three 12,500-kVA, 3-phase transformers which will be made by AEI Transformer Division.

One of the orders, placed by the Andrew Air Conditioning Co. Ltd., with Motor & Control Gear Division, is for fifty-six squirrel-cage motors of various types ranging in size from $12\frac{1}{2}$ to 75 h.p., for driving air conditioning fans; another, from Harland and Wolff Ltd., is for sixty-nine squirrel-cage and slipring motors from $\frac{1}{2}$ h.p. to 150 h.p. for operating car body presses. A third order, from Vickers-Armstrongs Ltd., also specifies motors for driving presses and covers thirteen slipring machines each rated at 75 h.p.

Other contracts cover the supply of four 70 h.p. squirrel-cage motors through John Lysaghts and Co. Ltd., for fan drives and ten pump motors rated from 125 to 150 h.p. through Hayward Tyler & Co., Ltd. In addition AEI motors will power the cranes being supplied by J.H. Carruthers & Co. Ltd., and the conveyor equipment by G. S. King Ltd.

Equipment being supplied by the AEI Heavy Plant Division for Halewood includes motors for driving reciprocating air compressors by Alley Compressors Ltd. They include five 850 h.p. 600 r.p.m., 0.8 p. f. synchronous induction motors; two 230 h.p., 428-r.p.m., 0.8 p.f. synchronous induction motors;

In effect, the railways have at their disposition two methods of traction—electric and diesel—both international and both integrating each other. It is impossible, today, to say where the boundary between them will lie, the day in which the last furnace dies in a steam locomotive. The technicians never rest in their constant search: the two camps, mechanical and electrical (and thermal when required), no longer stay far from one another, but come together and realise their importance one to the other, and the necessity to work together, in order to obtain, in the future, a more perfect and more economic locomotive.

together with liquid rotor-rating and field control cubicles.

The transformers ordered from the AEI Transformer Division cover the three main 3-phase units required for the factory. Each is rated at 12,500 kVA with a voltage ratio of 33/11 kV, and fitted with AEI high-speed resistor transition on-load tap changers.

* * * * *

NEW FACTORY TO MAKE AUTOMOBILE ELECTRICAL EQUIPMENT AT MADRAS

Lucas electrical equipment to meet the demands of the expanding Indian motor industry is to be manufactured by a new £2,000,000 company in Madras.

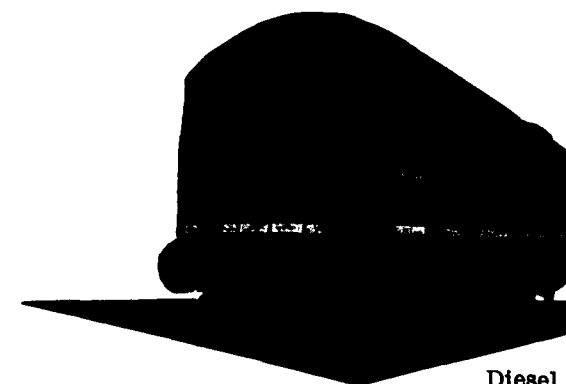
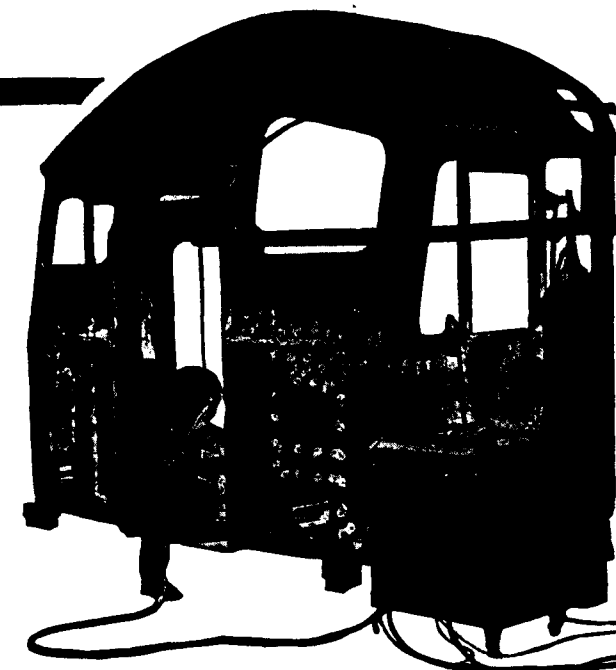
An announcement by Joseph Lucas Ltd., Birmingham, said: "Negotiations have been proceeding during the past few months between Joseph Lucas and T. V. Sundaram Iyengar & Sons (TVS), of South India, and a partnership agreement has now been signed initiating the formation of a new company."

The announcement said that capital employed in the new company would amount to more than £2,000,000, and this would include more than £1,000,000 worth of plant and machinery provided by Lucas. Initially some components will be imported, but a gradual change-over to indigenous production is planned.

Employment will be provided in the new company in the first phase for more than 1,000 Indian nationals in all grades from engineers to unskilled operatives, and initial production will commence in 1962 with the manufacture of electrical equipment and spares for commercial and private vehicles.

British Railways Diesel Unit

**fine
bodywork
welded by
Saturn-Hivolt**



Surge Injector Welding Units

One of the most modern British Railways locomotives in production today in this 1160 H.P. Diesel electric type, which is being constructed at Derby under the supervision of the Chief Mechanical Engineer (London Midland Region). Saturn-Hivolt argon arc welding equipment and Saturn High purity argon are being used extensively for the important welding of aluminium alloy which is being used to lighten the construction.

The Saturn-Hivolt argon arc surge injector has proved itself invaluable wherever first class welding of aluminium and its alloys is required. Ask for a demonstration in your own factory.

Delivery of a wide range of industrial gases, and prompt equipment maintenance service, are also operated by our branches throughout the country.

SATURN INDUSTRIAL GASES LTD



GORDON ROAD · SOUTHALL · MIDDLESEX

TELEPHONE: SOUTHALL 5611

AXLE-SUSPENDED TRACTION MOTOR FOR D.C. AND RECTIFIED A.C.

A SELF-VENTILATED axle-suspended traction motor has recently been developed by Crompton Parkinson Ltd., the motor, designated type C.152, being suitable for operation on D.C. systems and on rectified single-phase A.C. at industrial frequency. Commutation is very satisfactory even with ripple up to 30%, and with terminal voltage 20% above rated voltage, this being the result of skilful detail design. It is designed for a rated voltage of 750 volts, but is insulated for operation on a 1500 volts supply, and is therefore applicable to rectifier vehicles in dual operation on single-phase 50-cycles A. C. systems as well as on 1500 volts D. C. systems.

The motor conforms in every respect with B. S. 173, and is Class 'B' insulated throughout, armature and field coils being fully bakelised. Field weakening is obtained by means of tappings.

The ratings of the C.152 motor on rectified single-phase, 50-cycles A. C. are shown below.

Similar motors can be supplied for larger outputs—as required for main line locomotives, with forced ventilation and suitable flexible transmission. Alternative versions available have special high speed construction and lower outputs for use with cardan-shaft drives to high-ratio right-angle drive gearboxes.

The following ratings are those of the prototype machines having Class 'B' insulation; Class 'F'



Self-ventilated axle-suspended traction motor type C 152, made by Crompton Parkinson Ltd. This motor has been designed for operation on D.C. or on rectified single-phase A.C. at industrial frequency, with up to 30% ripple.

insulation is also available, and correspondingly higher ratings can be expected.

*C.152 Ratings at 57.5% Full Field
on Rectified Single-phase 50 c/s A.C.*

	<i>One Hour</i>	<i>Conti- nuous</i>
Output, h. p.	205	175
Ampères	225	190
Volts	750	750
Speed, r.p.m.	1500	1620
Maximum Service Speed—2580 r.p.m.		

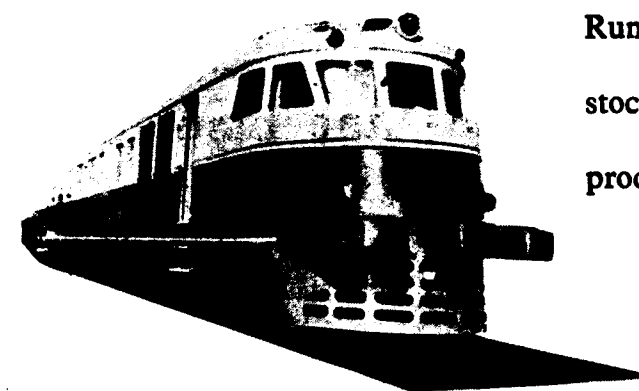
Weight complete with pinion and gearcase—4214 lb.

WORLD'S LONGEST ELECTRIC RAILWAY

Work is nearing completion on the electrification of the world's biggest railway line from Moscow to Irkutsk. Its length is 5,3000 kilometres. It is almost 50 per cent longer than all the railways of the United States using electric traction. The annual coal economy on this line will amount to 18,000,000 tons. The speed of trains will be much greater. Some 204,000 posts and 194 substations were needed to switch over the line to

electric traction.

New locomotives will be used on the Moscow-Irkutsk stretch. For the first time in the practice of railroad building, for instance, the line uses alternating instead of direct current on a big stretch. This, among other things, has yielded a big economy of copper.



Rumania's industry turning out rolling stock and boasting an old standing production tradition supplies through

INDUSTRIALEXPORT

STR. GABRIEL PERI NO. 2

BUCHAREST — RUMANIA

Cables: INDEXPORT

Telex: 265; Telephone: 116

- Open, covered and platform freight cars
- High capacity dumping cars and self-discharging cars
- Tank cars
- Railcars
- Diesel mine locomotives
- Mine tubes

Best quality materials

are used. The products are up to the latest requirements.



Silicone Treatment of Overhead-Line Insulators

H. L. Halstrom*)

Ktas

A summary is given of the behaviour of ordinary telephone insulators and silicone-treated telephone insulators under adverse weather conditions.

It is shown that the silicone treatment gives satisfactory results when performed IN SITU on dirty insulators.

THE primary constants of an overhead telephone line are unfortunately not to be regarded as constants in all the senses of this word. Although the capacitance and the inductance do not change very much under ordinary conditions, the resistance varies with the temperature of the surrounding air or by the effect of direct sunshine, and worst of all: the leakance may vary suddenly and abruptly within very great limits and can, under adverse weather conditions, attain such low values that the telephone line becomes practically unserviceable.

As it seemed possible to improve the figures for the leakance by means of silicone treatment, we became interested in the matter as early as 1952 when these oils became commercially obtainable in Denmark.

A preliminary investigation in the laboratory proved that the expected increase in insulation resistance could be realized, when the insulators were given a suitable silicone treatment before they were measured in a humidity chamber under varying conditions of artificial rain and high humidity.

Fig. 1 shows two insulators mounted on a bracket after having been exposed to artificial rain. The left one is treated with silicone and the right one is an ordinary untreated insulator. Though they look alike when dry, there is a marked difference in the way they react when being exposed to artificial rain. The untreated insulator is wet all over, while on the silicone treated insulator the moisture is broken up into small droplets, so that no continuous leakage path exists between the wire attached to the insulator and the earth-connected iron pin on which the insulator is fixed. This explains the surprisingly high insulation values measured on the silicone treated insulators.

An experiment was therefore begun in June 1953 to

*) Assistant Chief Engineer, Technical Department, Copenhagen Telephone Company.

find out if equally good results were obtainable in practice.

Ten new insulators of the smallest type were carefully cleaned by mechanical means, degreased by means of a solution of a suitable detergent, washed several times with distilled water and dried.

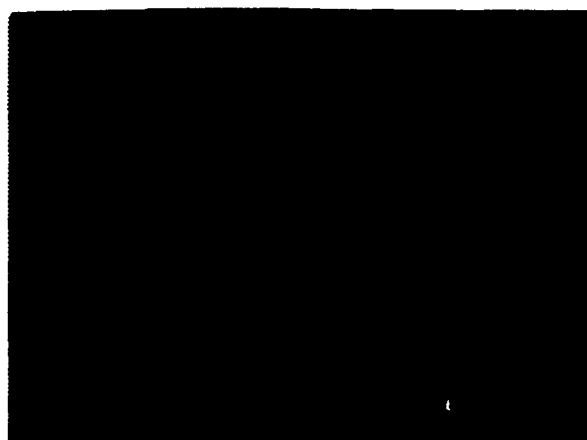
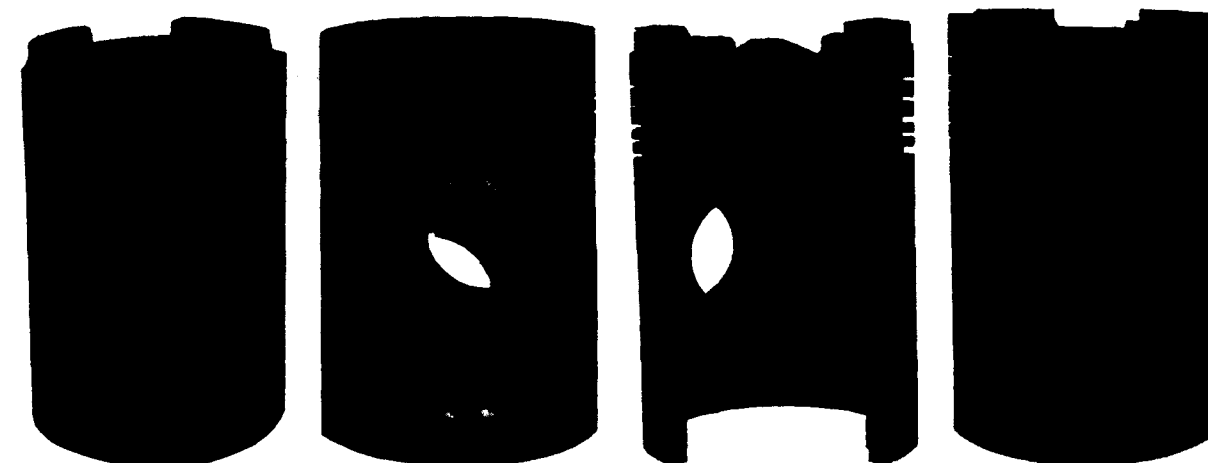


Fig. 1. Telephone insulators after having been exposed to artificial rain.

Five of the insulators were dipped in a 2% solution of a silicone oil in purified trichlor-ethylene, after which they were baked in a thermostat for 2 hours at 200°C. The five silicone treated insulators were together with the five untreated insulators mounted on an iron bracket attached to the railing of the balcony just outside the windows of the laboratory.

Insulation measurements were made on the insulators from time to time under different weather conditions from June 1953 to June 1955.

At the beginning of the experiment the insulation resistance of both the silicone-treated and the normal insulators were well above 1 million megohms, but after a lapse of 2 months, the untreated insulators



MAHLE piston with AL-FIN bonded ring carrier of special cast iron (Ni-Resist) and cast-in cooling serpentine, made of eutectic Al-Si alloy "MAHLE 124".

MAHLE piston with AL-FIN bonded double groove ring carrier of special cast iron (Ni-Resist) and cast-in cooling serpentine, made of eutectic Al-Si alloy "MAHLE 124".

MAHLE closed type piston with cast-in cooling serpentine, made of hypereutectic Al-Si alloy "MAHLE 138".

MAHLE closed type piston with cast-in cooling serpentine, made of eutectic Al-Si alloy "MAHLE 124".

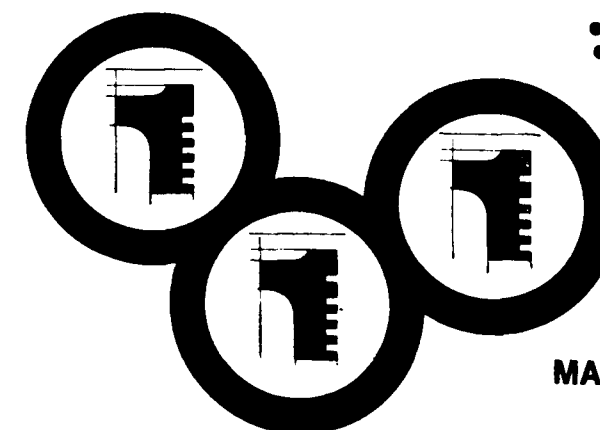
25 USA AND CANADIAN ROADS USE MAHLE PISTONS IN THEIR ALCO AND BALDWIN DIESELS

MAHLE Pistons

100 to 200% longer operation between overhauls

MAHLE aluminum pistons, cast or forged, are made of various eutectic and hyper-eutectic silicon alloys combining high tensile strength and resistance to wear. With or without internal oil cooling. MAHLE alloy 124 has 12% silicon content. Due to the structural distribution of the silicon and the careful supervision of all its ingredients, this eutectic alloy offers strength and wear properties superior to standard piston alloys. For excessive loads, AL-FIN-bonded

NIRESIST inserts are available also for Alco 244 and 251 engines. MAHLE first introduced iron ring inserts on aluminum pistons in 1931. MAHLE alloy 138 has 18% silicon content. This hyper-eutectic alloy insures outstanding resistance to wear. Its reduced coefficient of thermal expansion allows for narrowest clearances. Especially recommended for highly supercharged or high bmep engines operated in heavy duty road service. No insert required.



- 40 years of experience.
- Far over 100 million pistons in ALL sizes up to 20" diameter.
- Over 1 million aluminum cylinder liners. All chromium plated Al-liners in Porsche cars supplied by MAHLE.
- 100 European engine builders regularly use MAHLE pistons as original equipment.

MAHLE Komm.-Ges. Stuttgart-Bad Cannstatt
(West Germany)

showed a very low insulation resistance value during a heavy rainstorm. Dry weather and sunshine brought the insulation up again, but not to the high level at which the insulators started, and every subsequent rainstorm or other adverse meteorological condition, which might give rise to a deposit on the surface of the insulators, seemed to decrease the insulation of the insulators even during dry periods. Towards the end of the experiment the insulation resistance of the untreated insulators tended towards 10–30 megohms in overcast, dry weather, while every much lower values were obtained during humid conditions.

During the first year, i.e. from June 1953 to March 1954, the insulation resistance of the silicone treated insulators was above 10^4 Megohms, this being the upper limit of the range of the measuring instrument.

Fig. 2 was taken just after a snowfall in the spring of 1954. The insulation resistance values indicated above the insulators show that the values obtained for the untreated insulators were of the order of 20–30 Megohms, while values for the silicone treated ones were above 1 million Megohms, even though all the insulators were heavily covered with snow.

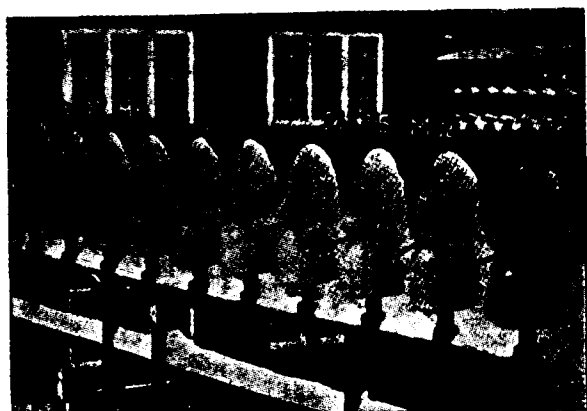


Fig. 2. Telephone insulators covered with snow. Spring 1954.

This was satisfactory, but unfortunately the effects of the silicone treatment were not sufficiently long lasting.

After about a year the insulation resistance of one of the silicone treated insulators dropped to the same level as for the untreated ones and after about 2 years all the silicone treated insulators had lost their excellent properties as regards insulation resistance and had become quite as bad as—but no worse than—the untreated insulators.

A renewal of the silicone layer would necessitate a cleaning and heat-treatment of the insulators, an operation which it would be impossible to perform if the insulators were mounted on the crossarms of poles or in other equally inaccessible places.

As the effects of the silicone treatment were of too short a duration and as a renewal of the treatment was impracticable, it did not seem possible to advocate the use of this treatment, even where its effects were greatly needed.

The appearance of silicone grease MS 4 seems to have altered the situation completely.

In the autumn of 1957 we got hold of a sample of silicone grease MS 4, which does not need to be "fixed" on the insulators by means of a heat-treatment, and we therefore decided to repeat the experiment with the insulators in a slightly different way.

The stores were asked to supply us with ten brand new insulators and ten of the most rough and dirty insulators they could find among the insulators returned to the stores, i.e. insulators which had been in use for a number of years and which were considerable the worse for wear.

All the twenty insulators were mounted on an iron bracket placed as in the previous experiment. The silicone was applied by means of a small garden-spray, five of the new and five of the old insulators being sprayed with a 10% solution of silicone grease MS 4.

Fig. 3 shows the ten new insulators on their bracket. The five insulators to the right are the silicone-treated ones. Owing to the thin layer of grease on the surface they have accumulated a certain amount of dust, for

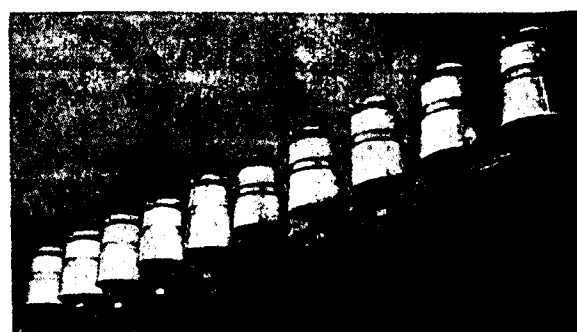


Fig. 3. New telephone insulators after two years' service.

which reason the untreated five on the left look much whiter.

As in the previous experiment, the insulation resistance was measured from time to time, but not at definite intervals. As the insulation was always well above the requisite values during good weather no measurements were made at these times, as the absolute value of the insulation resistance would then have been of no interest. The measurements were therefore only made under adverse weather conditions, the values thus obtained indicating the benefit obtained by the silicone treatment.

The results of these measurements will appear from Figs. 4, 5 and 6. It is worth notice that it has been necessary to use a logarithmic scale with six decades for these curves in order to accommodate the values for the insulation resistance for relatively the silicone treated and the untreated insulators, a fact that speaks for itself.

The vertical lines above each date connect the highest and the lowest of the insulation values and the length of this line therefore gives an indication of the deviation of these values. The mean values are connected by means of a line, which of course cannot be regarded as a curve from which values of the insulation resistance can be read. This line is only to be regarded as a "tendency-line" which makes it easier to follow the variation with time of the insulation resistance of the insulators.

Fig. 4 shows a comparison between new and old insulators under adverse weather conditions. None of

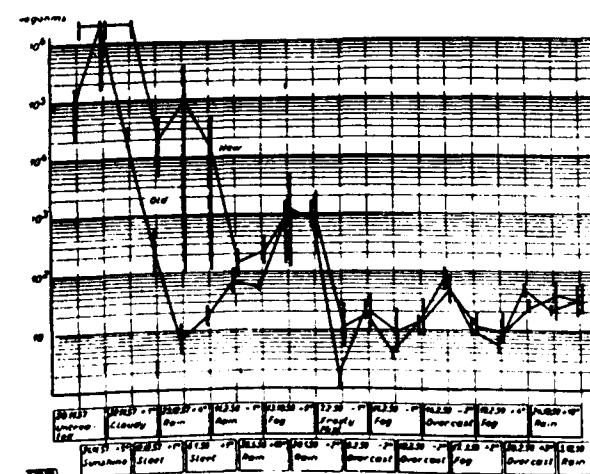


Fig. 4. Untreated insulators under adverse weather conditions.

these insulators have been silicone-treated. It can be seen from the curves that after having been in use for about 3 months during the winter, no difference can be observed between the values obtained for new and old insulators. A change-over from old and dirty insulators to new and clean insulators will therefore only mean a better performance for a very short time. The re-fitting of an overhead-line with new insulators is a very costly procedure, and if it mainly serves to satisfy an aesthetic need for cleaner insulators, it is a little doubtful if such an expenditure is warranted. It is also a question if it really pays to clean old insulators that have been returned to the stores. If this has to be done, the necessary mechanical cleaning ought to be done without scratching the glaze unduly as, from a transmission viewpoint, an insulator with a few dark spots is better than a white insulator with a thoroughly scratched glaze.

Fig. 5 shows the difference in insulation resistance for new insulators with and without silicone treatment. While the untreated insulators lose their good insulating properties in about 3 months, the silicone treated ones are not affected. The "tendency-line" for the untreated insulators goes down until it reaches about

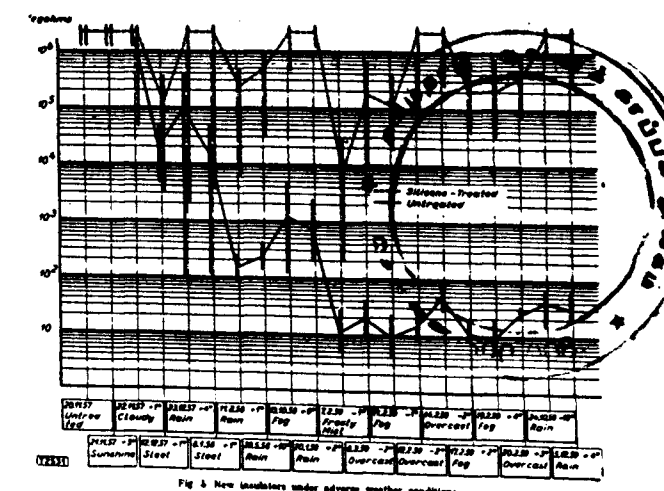


Fig. 5. New insulators under adverse weather conditions.

10 Megohms, while the "tendency-line" for the silicone-treated ones still (May 1960) is on the 10^5 – 10^6 Megohms. The two "tendency-lines" are showing the same fluctuations, obviously as a function of the same variable, i.e. the weather, the only real difference being that the insulation resistance is 10,000 to 100,000 times higher for the treated insulators than for the untreated ones.

SIDEREXPORT

2, Via Garaventa - GENOA (Italy) Telex : RM 014/111

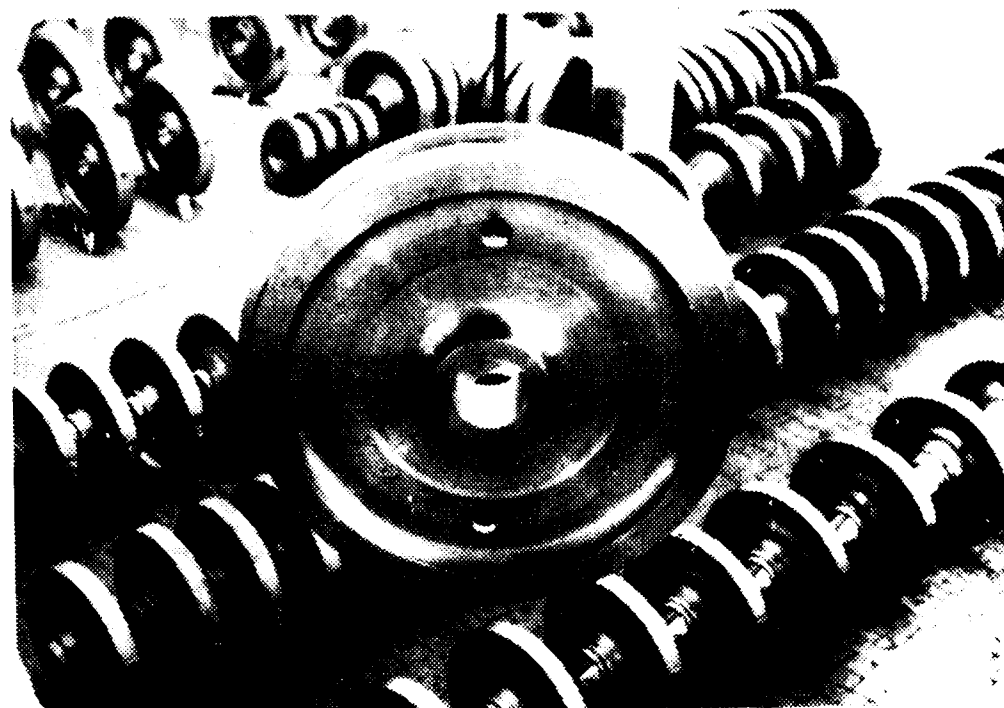


This concern of the Italian FINSIDER Group handles the sale abroad of the production of the following steelmaking companies:

ITALSIDER (Ilva & Cornigliano amalgamated companies) - Genoa
S.I.A.C. - Genoa DALMINE - Milan TERNI - Rome

During the past two years the Group's output raised up to 80 per cent of Italy's production of pig and 53 per cent of raw steel—Ever increasing percentage due to expansion plans under way of completion.

High quality and dependability — Any item in the steel line —



MAIN RAILWAY AND TRAMWAY MATERIALS

Rails - bearings plates - fishplates - clips plates - Steel sleepers - fishbolts and nuts - screw spikes - dog spikes - tyres - disc wheel centres - tyred wheels - solid wheels - carriage and waggon axles - locomotive axles - wheel sets (carriage, waggons, steam, electric and Diesel locomotives) - axles boxes - side buffers and loose members - central coupling buffers and loose members - hooks - drawbars, shackles, coupling screws - helical, laminated and volute springs - brake shoes

Railway Line Sales Agents in India:

SHANTA BROS. PRIVATE LTD.

Vaswani Mansions
Dinsha Wacha Road
Bombay 1

3 Hanuman Road
New Delhi 1

Fig. 6 shows the result of the silicone treatment an old and dirty insulators. Here also a pronounced difference is found between treated and untreated insulators. The silicone treatment increases the insulation resistance 100 times and even after the lapse of 2½ years there are no signs of deterioration of the silicone layer.

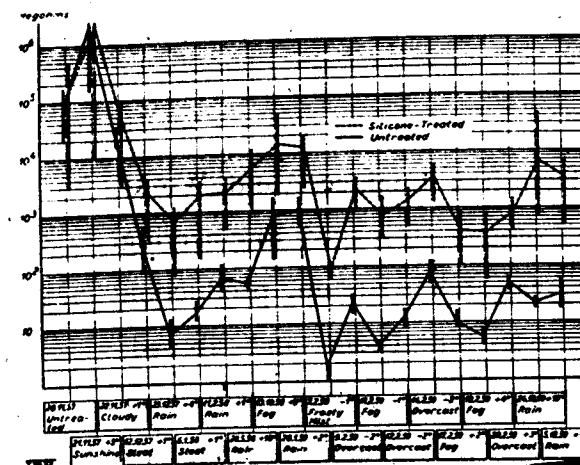


Fig. 6. Old insulators under adverse weather conditions.

On the basis of the above measurements it seems therefore reasonable to draw the following conclusions:

- (1) The silicone treatment causes a very considerable increase in the insulating resistance of the insulators under adverse weather conditions.
- (2) Under normal conditions the effects of the silicone treatment will last at least 2 or 3 years.
- (3) If the silicone layer on a silicone treated insulator deteriorates, it does not leave the insulator in a worse condition than if it had not been treated.

- (4) In case of a deteriorated silicone layer a new treatment can be given by spraying. This might even be done from the ground by means of an orchard spray working under pressure. In such a case proper precautions may have to be taken against high tension when spraying on joint constructions.

Normally a silicone treatment of telephone insulators will not be necessary, but there are cases where it might be an advantage to treat the insulators even at the cost of higher maintenance charges, if the silicone treatment can keep lines serviceable, which otherwise might not be the case.

Among such cases are:—

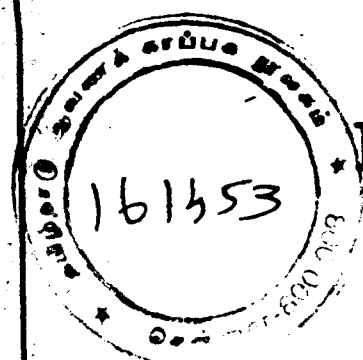
- (1) Overhead lines, exposed to frequent rain of long duration, snow, rime, hoar frost or white frost, mist, fog and "blue fog", etc.
- (2) Overhead lines which have been sufficiently good for local battery working, but where a change-over to automatic working might necessitate putting the overhead lines in cable and this latter eventuality is not desired at the same time.
- (3) Overhead lines with carrier channels.
- (4) Long overhead lines through sparsely populated regions with poor facilities for maintenance.
- (5) Overhead lines under tropical conditions.

(By Courtesy of Off-print of *TELETEKNIK*, English Edition, Vol. IV, 1960 No. 1)

Instrument for Measuring Meteorological Factors

An instrument which records variables like temperature, rainfall, wind speed, and water levels has been developed in Australia by Dr. C. J. Sumner, of the Australian Commonwealth Scientific and Industrial Research Organisation in Melbourne. It was developed at the Organisation's Division of Meteorological Physics, and will record information on the variables

for periods up to twelve months while unattended. The measurements recorded appear as a line of small holes on a chart, and they can be converted to a form suitable for automatic analysis on a computer. The instrument is powered by dry batteries, and includes a lens so mounted as to focus the sun's image on the chart each day and to burn a hole in it.



EDITORIAL NOTICE

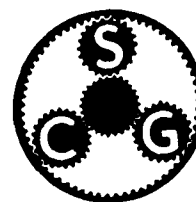
The Editor invites contributions from the Engineers and Works Managers of Railway Workshops as well as company-managed Engineering Workshops in the form of original articles, research write-up, production technique etc. relating to Workshop practices in India and abroad. Besides, suggestions for the technical improvement of various aspects of Railway Workshop practice are also invited with suitable write-ups accompanied by photographs wherever possible.

Contributions are accepted on the distinct understanding that they are sent solely to "THE INDIAN RAILWAYS WORKSHOP MAGAZINE". The Editor accepts no responsibility for the views and statements of the contributors.

All contributions intended for publication in any particular issue should reach the Editor at least 30 days prior to the scheduled date of publication. This Journal is issued quarterly i.e. February, May, August, November.

All published contributions are paid for at our usual rates.

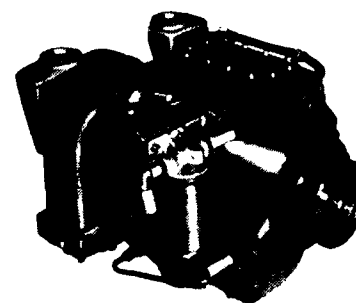
Editor



TRANSMISSION SPECIALISTS



THIS RAILCAR IS ONE OF THE MANY NOW OPERATED BY THE INDIAN STATE RAILWAYS, AND IS FITTED WITH THE S.E.4 GEARBOX AND RF 28 FINAL DRIVE



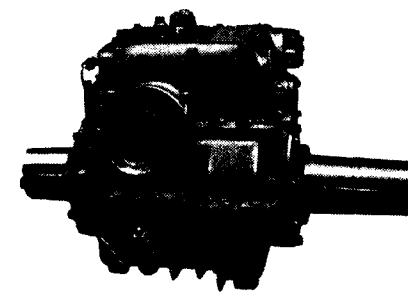
TYPE R.14 GEARBOX

POWER CAPACITY:
500 lb. ft. max input torque (69 mkg)

GEAR RATIOS:
1st speed-4.28:1 2nd speed-2.43:1
3rd speed-1.59:1 Top speed- 1:1

AIR PRESSURE:
For full rated capacity 60/65 lb. per
sq. in. (4.22/4.57 Kg. per sq. cm.)

WEIGHT: 498 lb. (226 Kg)



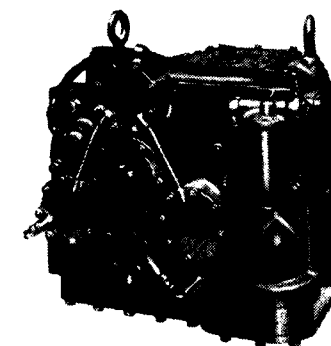
TYPE RF.28 FINAL DRIVE

POWER CAPACITY:
3000 ft. lbs. (415 mkg)

GEAR RATIOS AVAILABLE:
3.95:1 3.67:1 3.41:1 3.18:1
2.97:1 2.78:1 2.60:1 2.44:1
2.28:1 2.14:1

AIR PRESSURE: 60/75 lbs. per sq. in.

WEIGHT APPROX:
10 cwt. less Axle (508 Kgms)



TYPE S.E.4 GEARBOX

POWER CAPACITY:
750 lb. ft. max input torque (104 mkg.)
GEAR RATIOS:
1st speed-4.25:1 2nd speed-2.408:1
3rd speed-1.59:1 Top speed- 1:1
AIR PRESSURE:
75/80 lbs. per sq. in. max
(5.27/5.62 Kg. per sq. cm.)
APPROX. WEIGHTS:
Nett Weight:
7 cwt. 3 qrs. Cast Iron Casing (394 Kg)
5 cwt. 0 qrs. Aluminium Casing (255 Kg)
Gross Weight:
9 cwt. Cast Iron Casing (458 Kg)
6 cwt. Aluminium Casing (305 Kg)

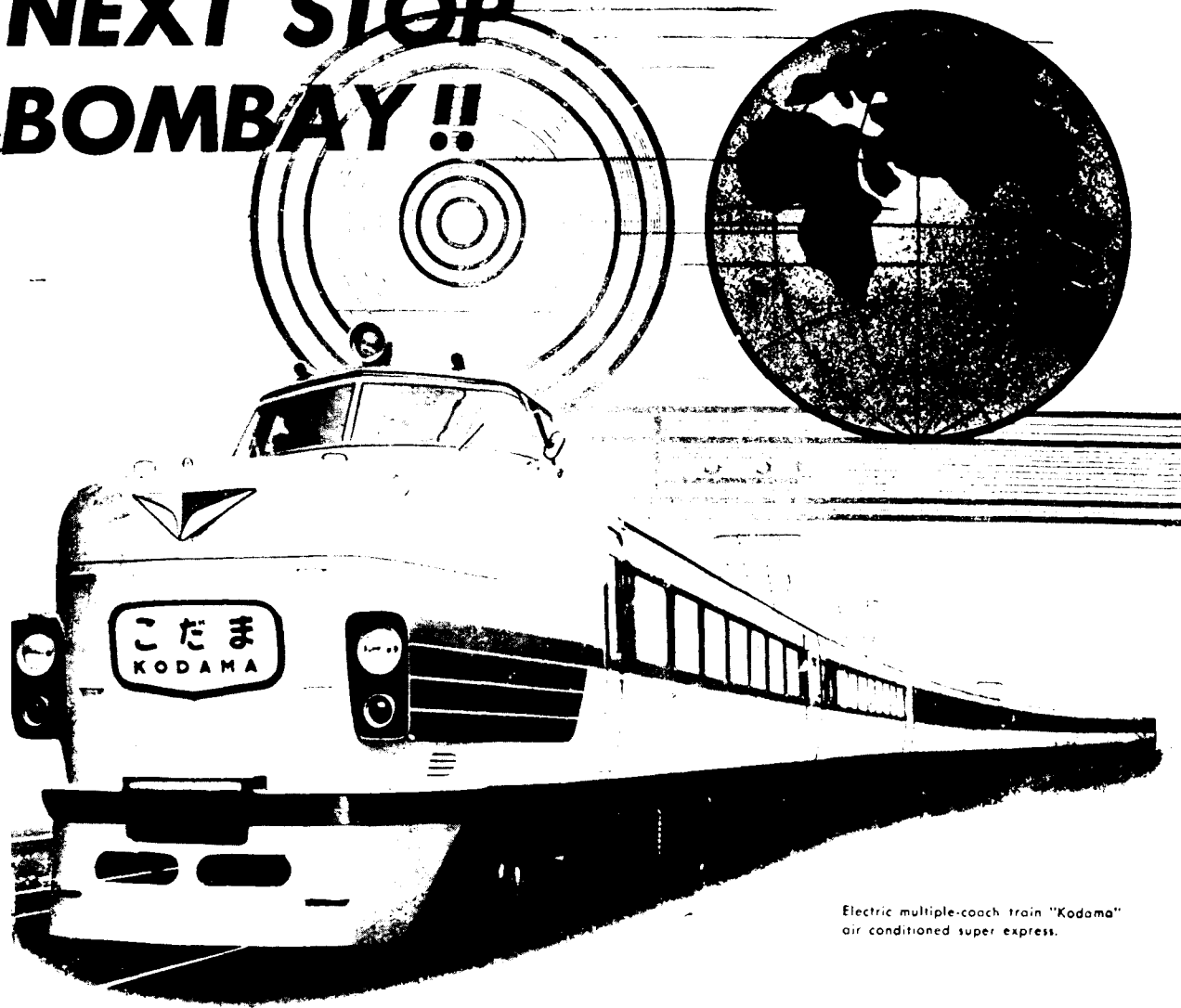
WRITE FOR FULL DETAILS OF THESE INTERESTING UNITS TO :

Self-Changing Gears Ltd.

Patentees and Makers of Wilson Gearboxes

LYTHALLS LANE - COVENTRY - ENGLAND

Toshiba
**NEXT STOP
BOMBAY !!**



Electric multiple-coach train "Kodama" air conditioned super express.

Next stop Bombay—or maybe it's Rio de Janeiro—for there's no way of telling where Toshiba's modern, smartly-designed electric coaches will be going next. Yes, Toshiba is making the kind

of modern electric equipment that is serving to help implement large-scale electrification programs in countries all over the world. Let Toshiba's experience in the field work for you!

TOKYO SHIBAURA ELECTRIC CO., LTD.

2, Ginza Nishi 5-chome, Chuo-ku, Tokyo, Japan.

Cable: TOSHIBA TOKYO

3

[illegible]