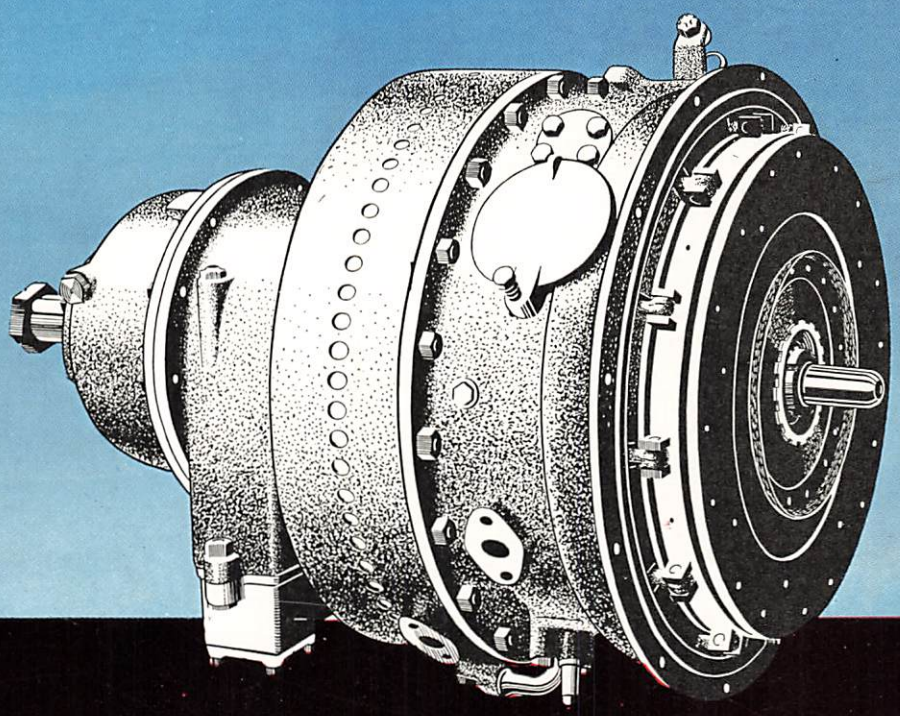
THE ATLAS DIESEL

HYDRAULIC TORQUE CONVERTER

SYSTEM LYSHOLM SMITH



Atlas Diesel AB

AKTIEBOLAGET ATLAS DIESEL STOCKHOLM SWEDEN

AtlasDiesel

VII. 47. 4000.

Catalogue No. 900.

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HYDRAULIC TORQUE CONVERTER

LYSHOLM-SMITH SYSTEM

AKTIEBOLAGET ATLAS DIESEL
STOCKHOLM - SWEDEN

SOME OUTSTANDING ADVANTAGES OF THE ATLAS DIESEL TORQUE CONVERTERS

(Lysholm-Smith System)

Comparison with mechanical transmission

1 Smooth power—long life

Hydraulic drive with the Atlas Diesel Torque Converter gives a perfectly smooth power transmission at all speeds. As no shocks can be transmitted through the converter the strains on engine, transmission and all other parts of the vehicle are reduced to a minimum.

2 Silent power—comfort

The smooth power application and complete silence in operation provide a high degree of comfort for the passengers.

3 Simplicity of control

The hydraulic torque converter produces a torque which varies automatically with the speed and the power transmitted is controlled exclusively by the engine speed. No gear change lever or clutch pedal exists. The control of the Atlas Diesel Hydraulic Torque Converter is therefore as simple as possible.

4 Multiple-unit control

The simplicity of control makes the Atlas Diesel Torque Converter particularly suitable in cases where more than one engine with transmission have to be controlled from a single operating position. The Atlas Diesel Torque Converter is therefore the ideal transmission for multiple-unit trains.

5 Rapid acceleration

The Atlas Diesel Torque Converter operates with a high mean efficiency and makes it possible to utilize the full engine power at all vehicle speeds. Smooth and rapid acceleration is obtained as there is no manual gear change with consequential time lag. With Atlas Diesel Direct Drive Converters the losses at normal cruising speeds are brought down to an absolute minimum.

Comparison with electric transmission

6 Simplicity in design, lightness, low cost of installation and maintenance

The Atlas Diesel Torque Converters have all the advantages and none of the disadvantages of electric transmission as they are considerably lighter, simpler, cheaper and take less space. The reliability of hydraulic transmission is high on account of its simplicity in design and ease of operation, thus involving a minimum of maintenance.

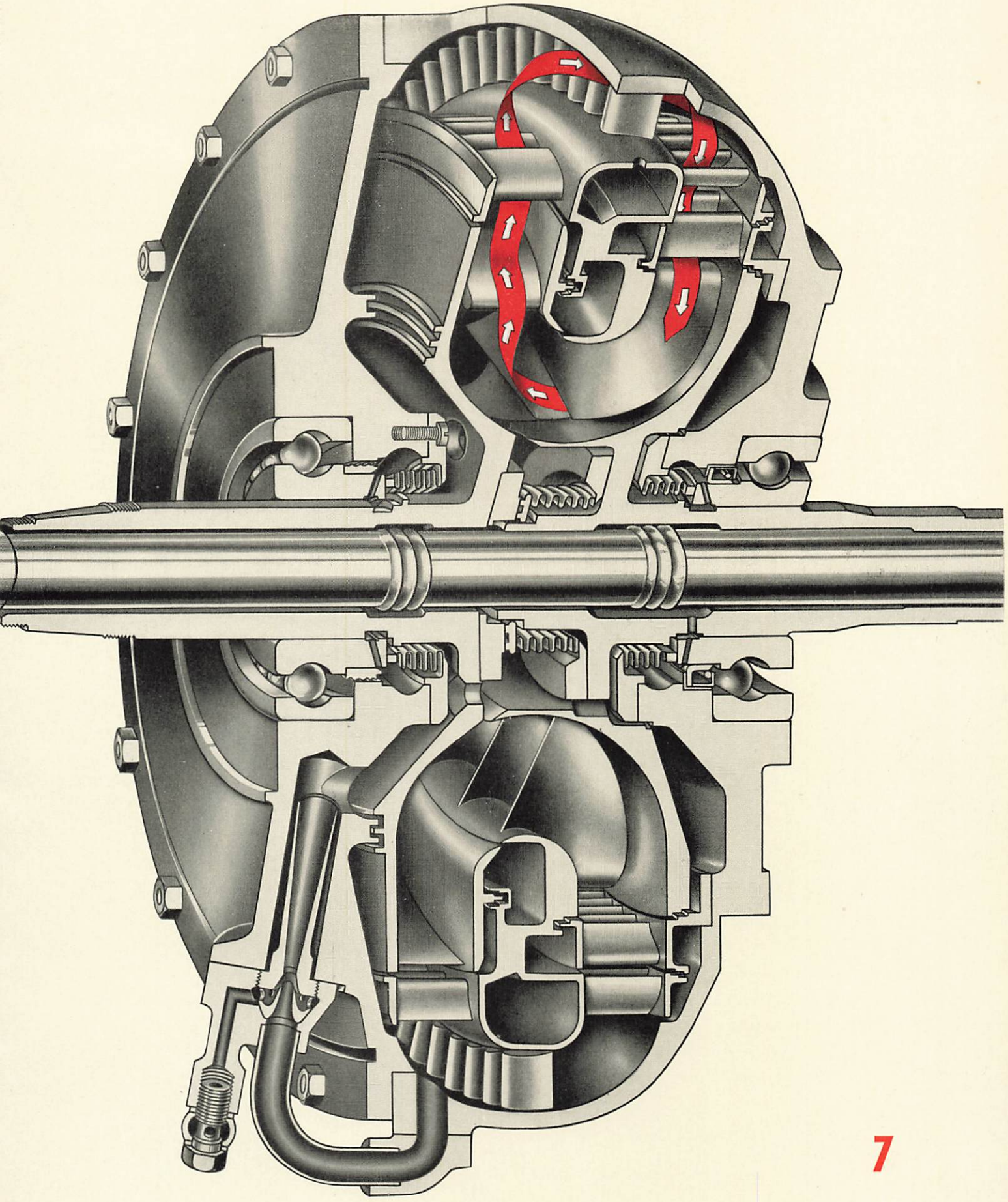
Foreword

As distinct from the steam engine the internal combustion engine develops a maximum torque, which is practically constant regardless of the speed. For automotive work where the torque demand varies with the resistance of the vehicle and with the acceleration requirement, the internal combustion engine must be combined with a torque converter which is able to convert the engine torque at full engine speed into a higher torque at a correspondingly lower speed of the output shaft. Until now the torque converter has generally been of mechanical type for small outputs and of electric type for large outputs. The hydraulic torque converter has, however, during recent years become highly popular for traction work. The reason for this is that hydraulic transmission combines the low cost of installation, low weight, ease of maintenance and low upkeep cost of mechanical transmission with the smooth and simple operation of electric transmission. The hydraulic torque converter comes nearer the ideal than any other form of transmission as it provides an automatically variable torque-speed range.

The design of Atlas Diesel Torque Converters is based on exhaustive research in well equipped experimental laboratories, experience gained from units in service and close collaboration with the license holders, the Ljungströms Ångturbin Company, Stockholm. They are manufactured in the Atlas Diesel Works at Stockholm and all parts are machined with the highest degree of precision from the best material obtainable. Before delivery each unit is carefully tested over the entire operating range.

This catalogue contains a brief description of the Atlas Diesel Torque Converters. The nature of hydraulic torque converters is such that no broad statements or rules regarding their application can be made. Each installation must be individually analysed and designed to ensure the best performance. The Atlas Diesel Hydraulic Department is able to give you the best solution of your transmission problem. You are cordially invited to make use of this service.

Sectional view of the Atlas Diesel Torque Converter.
The red ribbon indicates the circulation of the fluid.



Design and working principle of the converter

The Atlas Diesel Hydraulic Torque Converter in its simplest form is diagrammatically shown below. The construction is based on the hydro-kinetic principle and consists of a pump P and a turbine T concentrically built together in a stationary housing.

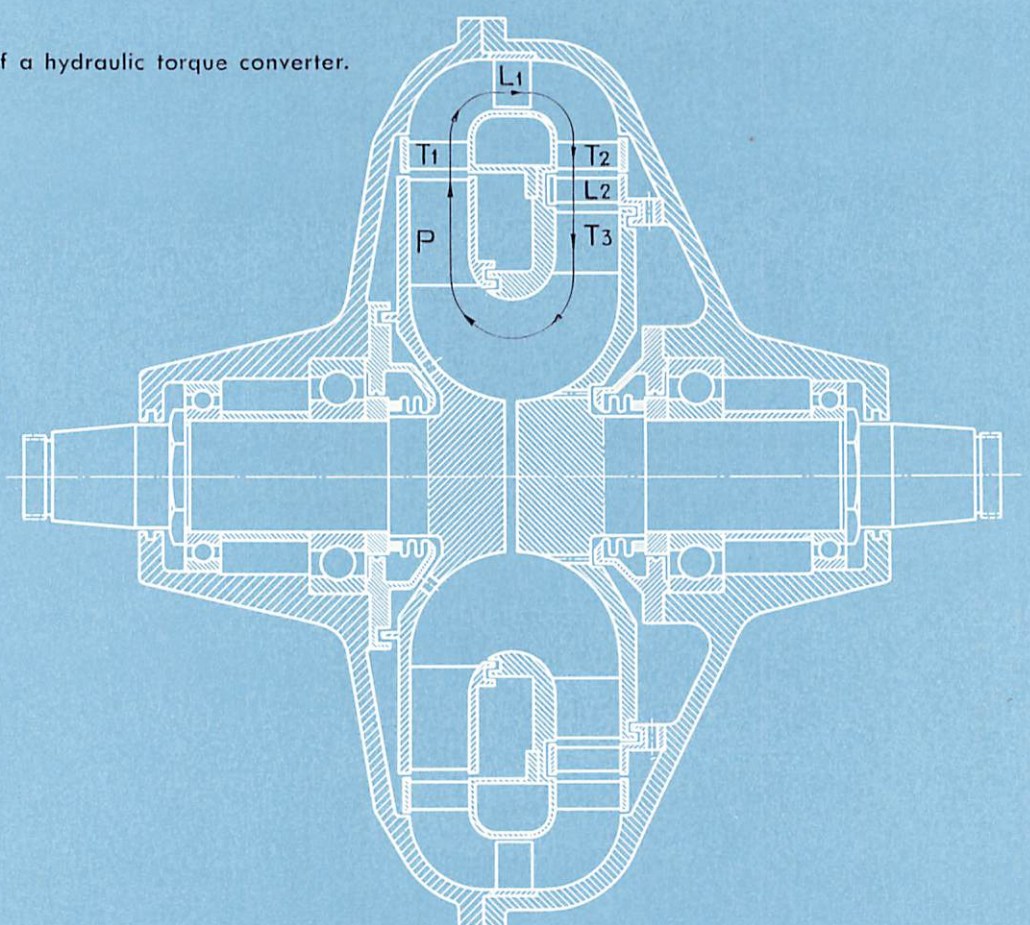
The pump,

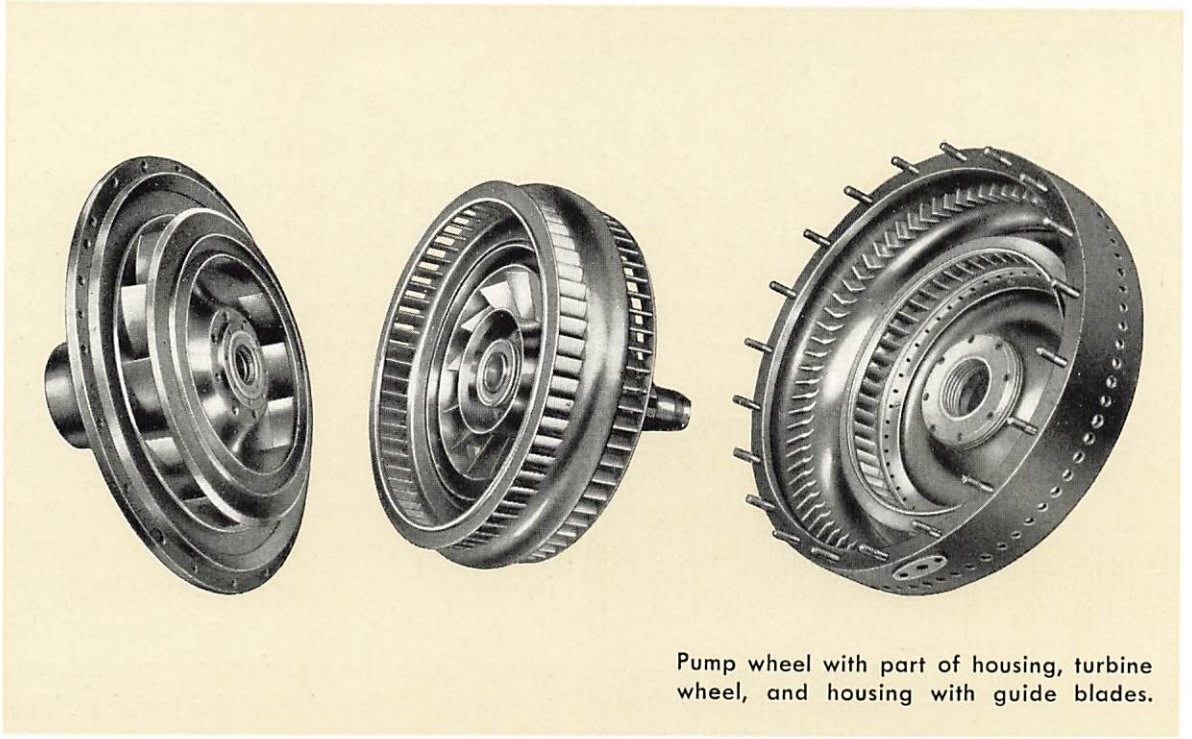
which is generally coupled direct to the engine, acts as an ordinary centrifugal pump. It absorbs the power delivered by the engine and converts it into fluid circulation in the direction indicated by the arrow in the illustration.

The turbine,

which is connected to the output shaft, consists of a rotor on which are mounted three separate rows of blades T_1, T_2 and T_3 forming a three stage turbine. The circulating fluid forces the turbine to rotate in the same direction as the pump with a torque which varies with the pump and turbine. With constant engine output the torque of the turbine varies inversely as the speed and

Section of a hydraulic torque converter.





Pump wheel with part of housing, turbine wheel, and housing with guide blades.

the maximum torque will be obtained when the output shaft is completely stalled.

In the stationary housing two rows of blades L_1 and L_2 are mounted, located between each of the three turbine stages respectively. The function of these stationary blades is to redirect the flow from the previous moving blades so that it meets the next row at the correct angle.

The stationary blades thus absorb the reaction torque which arises when the output torque is greater than the engine torque.

The fluid circulation inside the torque converter is clearly shown in the diagrammatic cut-away *(page 7)*.

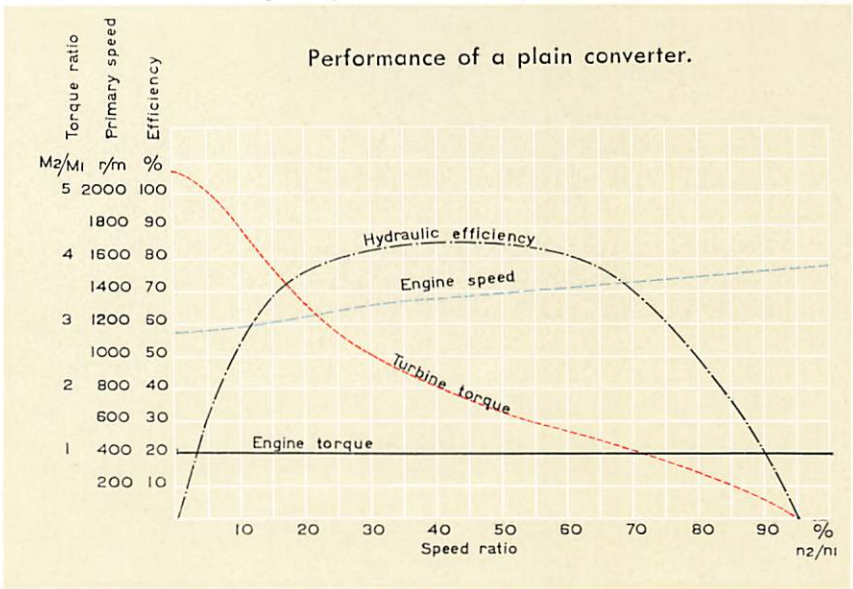
The housing is always completely filled with fluid, which is retained by means of seals. These generally consist of a lead bronze ring which is held in contact with a hardened and ground ring of special steel by a spring bellows of special metal. A small amount of leakage passes these seals to lubricate them and is collected in a sump under the converter.

The fluid accumulated here is automatically returned by an aspirator to a reserve tank above the converter. The aspirator is operated by means of a continuous flow of fluid under pressure, coming through a pipe from the top of the converter into the reserve tank. Any gas which may have been formed in the converter is separated from the fluid through the aspirator.

Fluid from the reserve tank is fed into the converter on the low pressure side of the pump rotor by an injector mounted on the converter housing and operated in the same way as the aspirator. The replacement of the fluid in the converter thus takes place automatically without any moving parts. The injector builds up pressure in the housing on the low pressure side of the pump and this pressure prevents any cavitation arising.

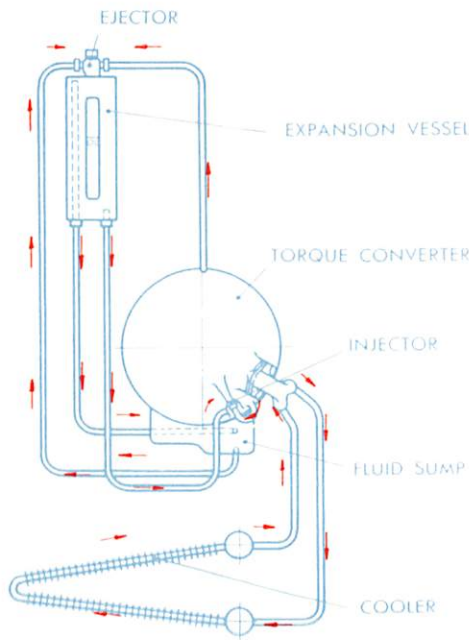
Performance characteristics

The performance of a plain converter is made clear by the diagram below. As the converter pump absorbs power proportionally to the cube of the engine speed, the pump will act as a very effective regulator for the engine speed. The size of the converter pump must therefore be carefully proportioned to the engine power and speed so that the full engine power can be utilized at full engine speed. The diagram is based on the assumption that the converter pump is driven by an engine with constant torque. As shown in the diagram the pump torque is slightly influenced by the turbine speed in such a way that the torque increases with a decrease in turbine speed. Owing to this torque increase there is approximately 20 % drop in the engine speed over the range from the maximum speed down to the stalling point of the turbine. The operating range of the output shaft is from 0, called the stalling point, to approximately 70 % of the corresponding engine speed. At this point the torque available at the output shaft is equal to the engine torque. At the stalling point the torque of the output shaft is approximately five times the engine torque.



The efficiency curve of the converter is rather flat with a peak of approximately 85 %. The reason for the fact that the efficiency varies with the speed ratio is that the pump and turbine blade angles can be arranged to suit each other exactly at only a certain ratio between the pump and turbine speed. At all other speed ratios the angles are not so favourable thus causing losses. In the Lysholm-Smith design the patented profile of the blades and the injector feeding system enable these losses to be kept at a minimum.

The loss of efficiency causes a temperature rise of the fluid within the converter. A portion of the fluid delivered by the converter pump is therefore continuously circulated through a separately arranged radiator. From the radiator the fluid returns automatically to the low pressure side of the converter pump. The capacity of this auxiliary cooling system varies with the type of service. In most cases, however, the cooling system should be capable of dissipating the heat equivalent to 25—30 % of the power developed by the engine.



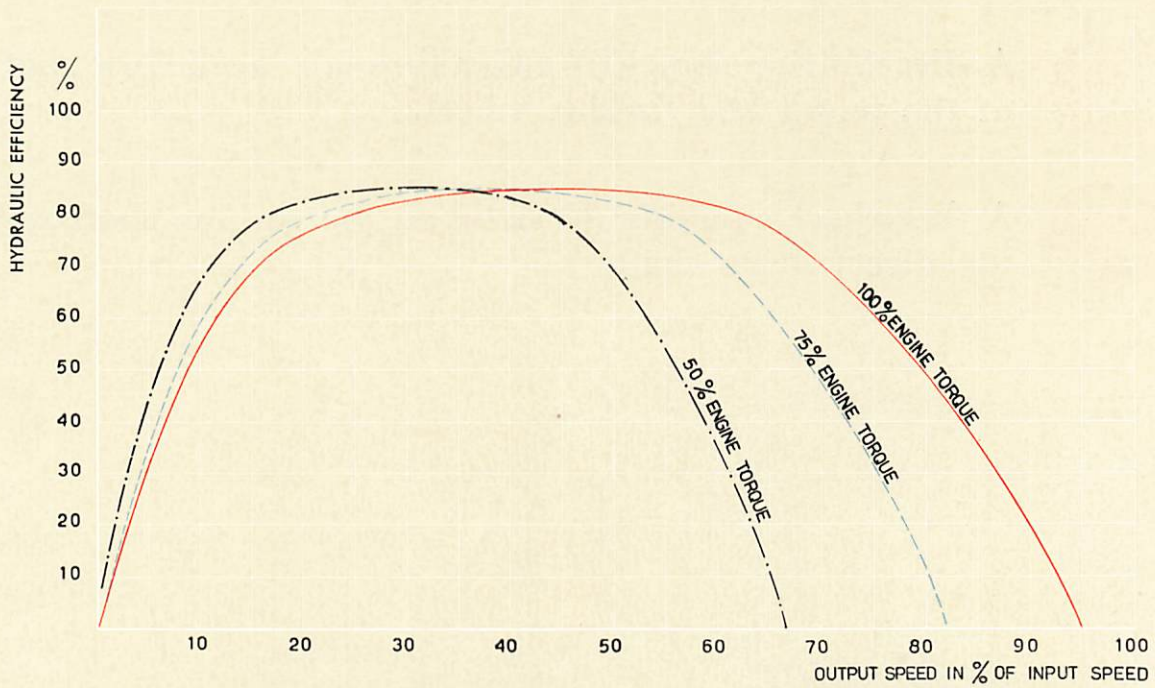
Fluid circulation outside the torque converter.

Torque control

When the converter pump is coupled to an engine developing a fixed torque, the output torque will automatically vary with the output speed.

At a steady output speed the torque is controlled merely by adjusting the engine speed. The converter pump torque varies as the square of the engine speed and when the speed is reduced to $^1/_2$ the torque will be reduced to $^1/_4$. The efficiency of the converter is a function of the speed ratio and not of the engine power.

If at any steady output speed the engine speed is reduced, the converter efficiency will alter and correspond to the new speed ratio regardless of the power transmitted.



The efficiency at some different engine torques.

Different types of hydraulic torque converters

It is apparent that the simple converter described above for automotive work should incorporate a means of cutting off completely the power flow through the converter. This can be arranged by means of a clutch installed between the engine and the converter or by a ring valve by which the fluid stream from the pump to the turbine can be cut off. Two types of Atlas Diesel Hydraulic Torque Converters are built—the direct drive converter with clutch arrangement and the ring valve torque converter. Both types are manufactured in various sizes to suit a wide range of engine power. In every size the blades can be modified within the capacity range of the converter to suit the torque speed characteristics of the engine with which the converter is to operate.

The direct drive converter

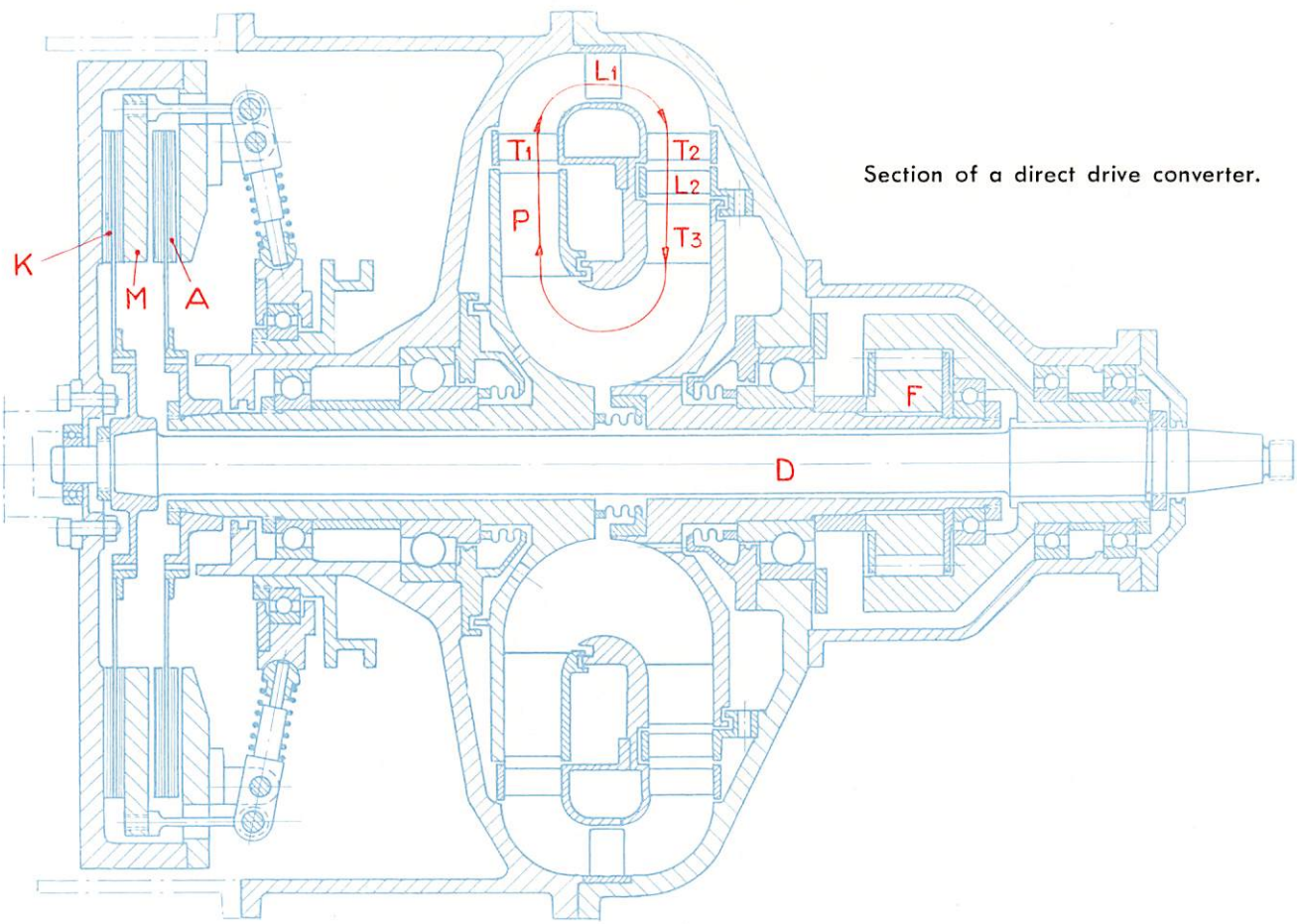
The direct drive converter as shown in the sectional drawing below consists of:

1. **A hydraulic torque converter (P, T, L) of the same type as earlier described.**

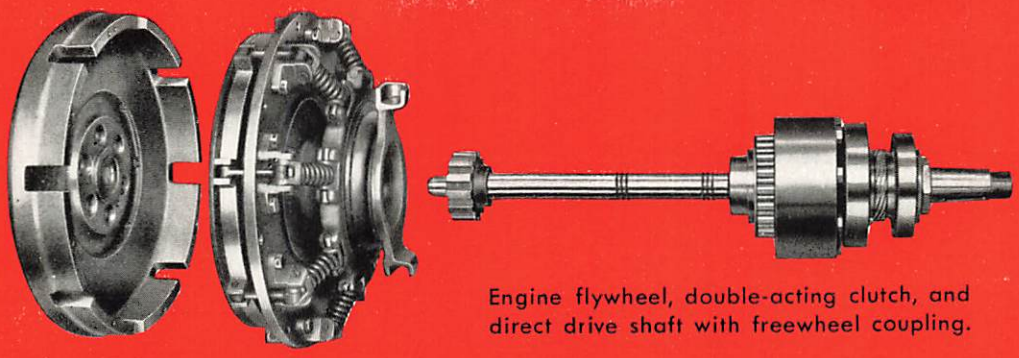
2. **A double acting clutch (KMA).**

3. **A direct drive shaft (D) going through the hollow shaft of the pump and turbine wheel.**

4. **A freewheel coupling (F) between the turbine shaft and the direct drive shaft.**



Section of a direct drive converter.



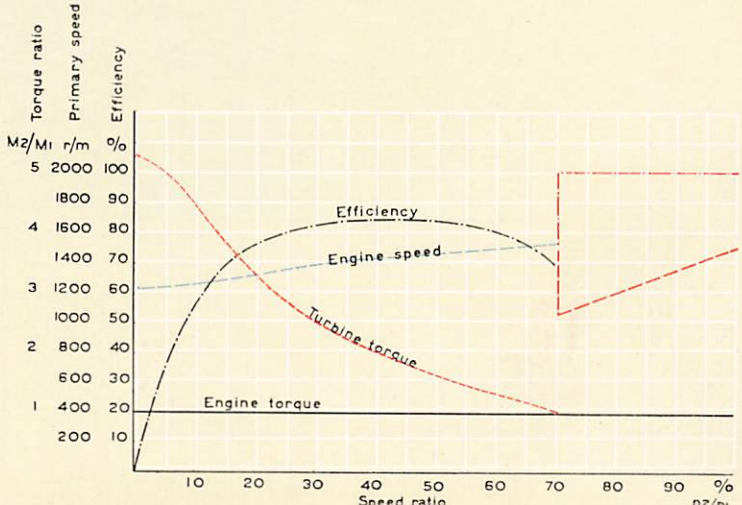
Engine flywheel, double-acting clutch, and direct drive shaft with freewheel coupling.

The double acting clutch contains two friction plates A and K of which A is mounted on the hollow pump shaft and K nearest the engine on the direct drive shaft. By the clutch plate M, which has a spring-loaded overcentre action, the drive is taken either through the friction plate A or K, giving hydraulic and direct drive respectively.

For hydraulic drive the hollow turbine shaft is connected to the direct drive shaft through a freewheel coupling which permits the turbine to come to rest when the direct drive is engaged. When driving direct all hydraulic losses are eliminated and the efficiency reaches approximately 100 %. The freewheel consists of rollers located in a cage between an inner cam and an outer race. When the hydraulic drive is engaged the rollers transmit the drive from the cam to the outer race. For direct drive the outer race »over-runs» the cam, and the rollers drop back into the recesses of the cam. Ample lubrication for continuous operation is provided by constant circulation of oil through the freewheel.

The performance curves for a direct drive converter are shown in the diagram below. The change from hydraulic drive to direct drive should be made when the output torque equals the input torque, which point occurs at about 70 % of the maximum vehicle speed. Thus the hydraulic drive is used for starting and accelerating the vehicle until 70 % of the maximum speed has been reached. The direct drive is used for normal propulsion at high speed. Compared with a conventional three speed mechanical gear box the hydraulic drive corresponds to the first and second gears and the direct drive to the third gear.

The direct drive converter is particularly suitable for such applications as buses and railcars. It has also found wide-spread use for small shunting locomotives in which the hydraulic drive is used for the normal shunting work and the direct drive for hauling light trains over longer distances at high speeds.

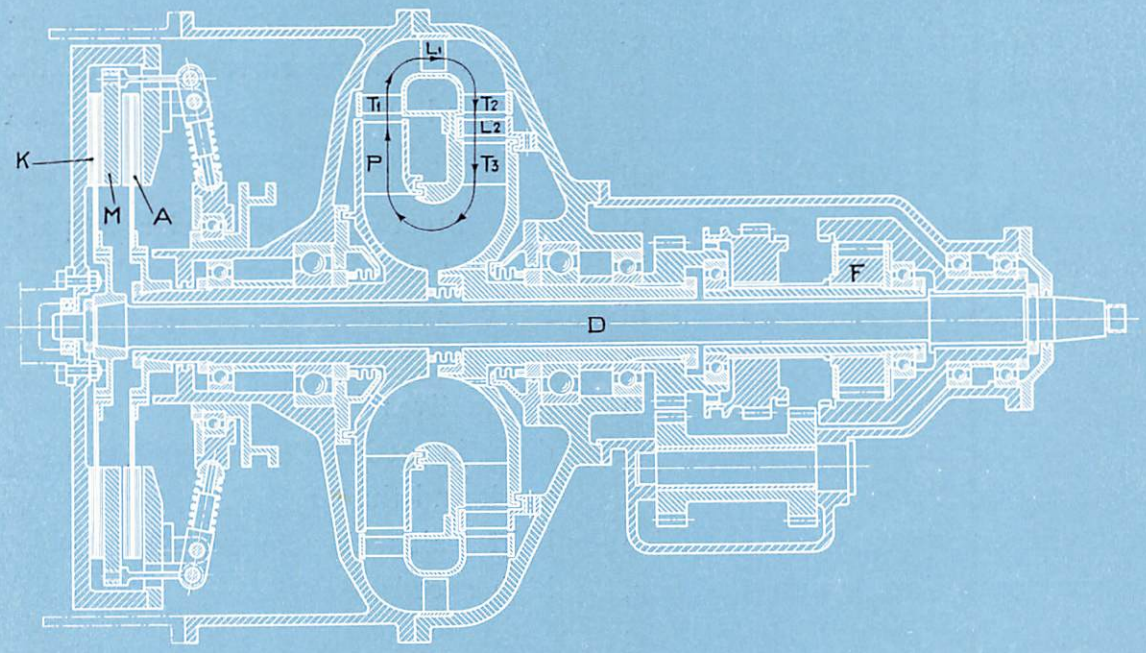


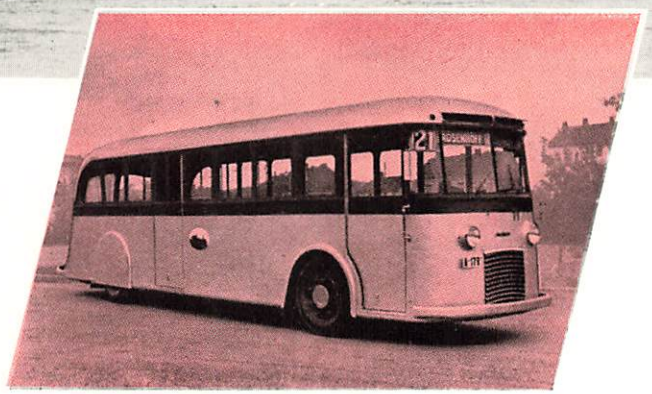
Performance of a direct drive converter.

The direct drive converter for buses

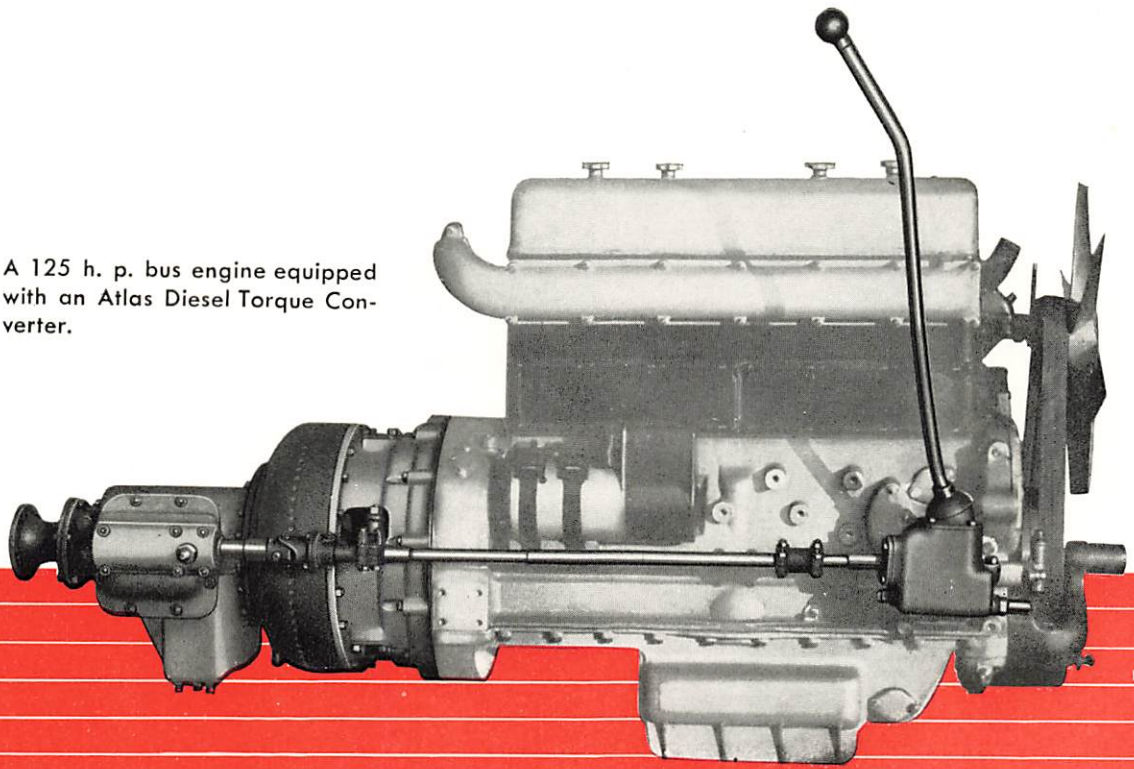
The direct drive converter for buses is built in combination with a reverse gear of the conventional layshaft type. The converter with the reverse gear is bolted to the engine flywheel casing and has about the same form, size and weight as a normal gear box. The reverse gear and the double-acting clutch of the converter are controlled by a single handlever in the driver's cab.

Section of a direct drive converter with reverse gear for buses.





A Swedish bus (above) and a Norwegian bus (to the right), both fitted with Atlas Diesel Hydraulic Torque Converters.

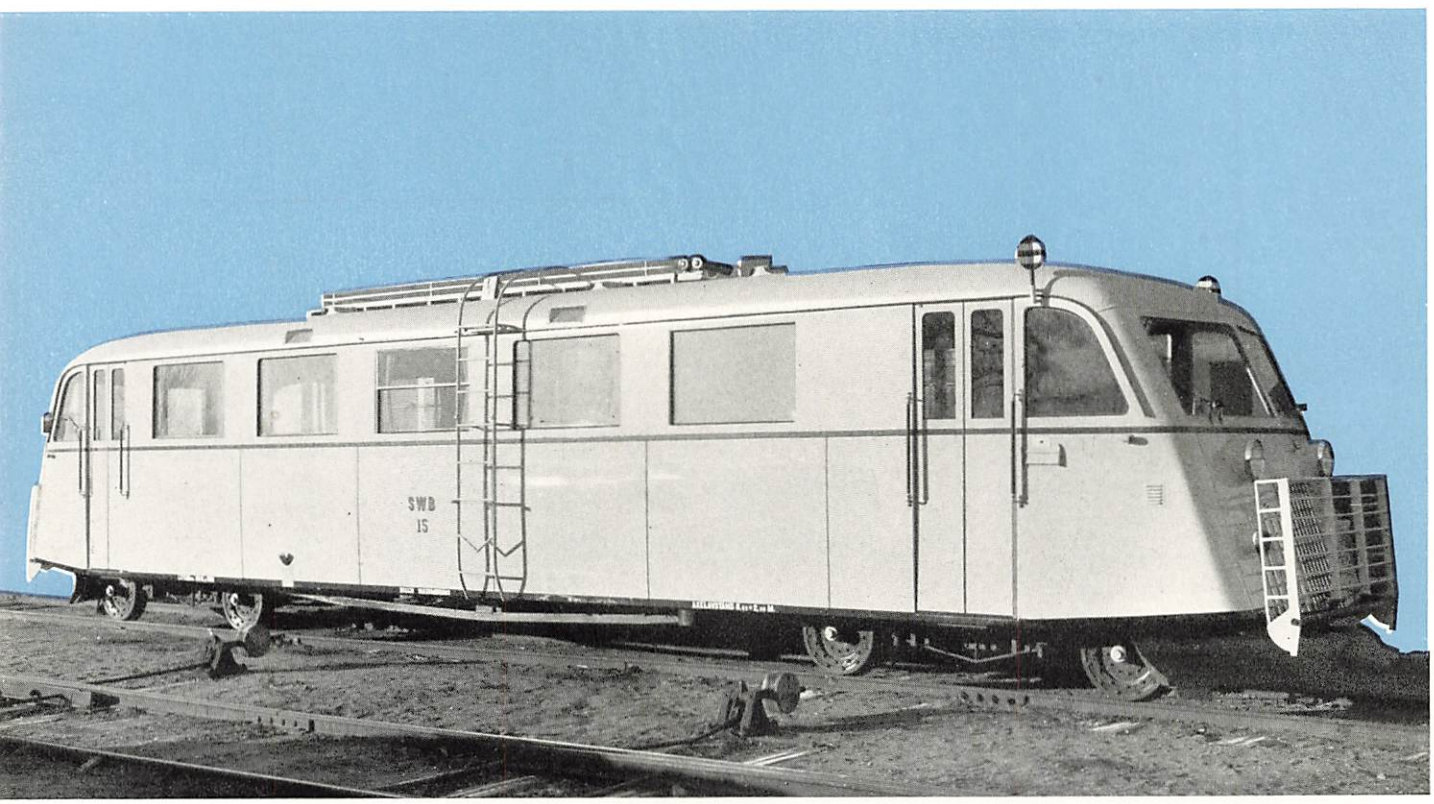


A 125 h. p. bus engine equipped with an Atlas Diesel Torque Converter.

The direct drive converter for railcars, multiple-unit trains and shunting locomotives

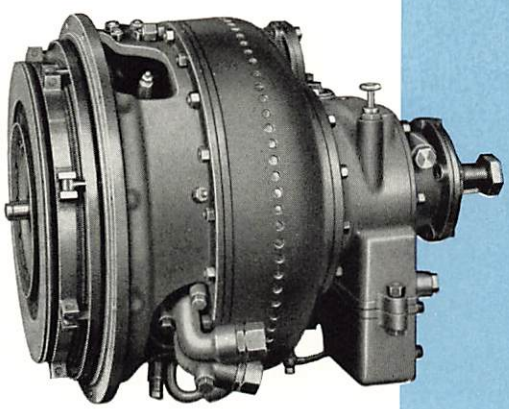
The direct drive converter for rail traction does not usually include a reverse gear as this is more often embodied in the driving axle. When two axles are to be driven from one converter, this must be combined with an auxiliary distribution gear box with two output shafts and usually includes the forward and reverse gear.

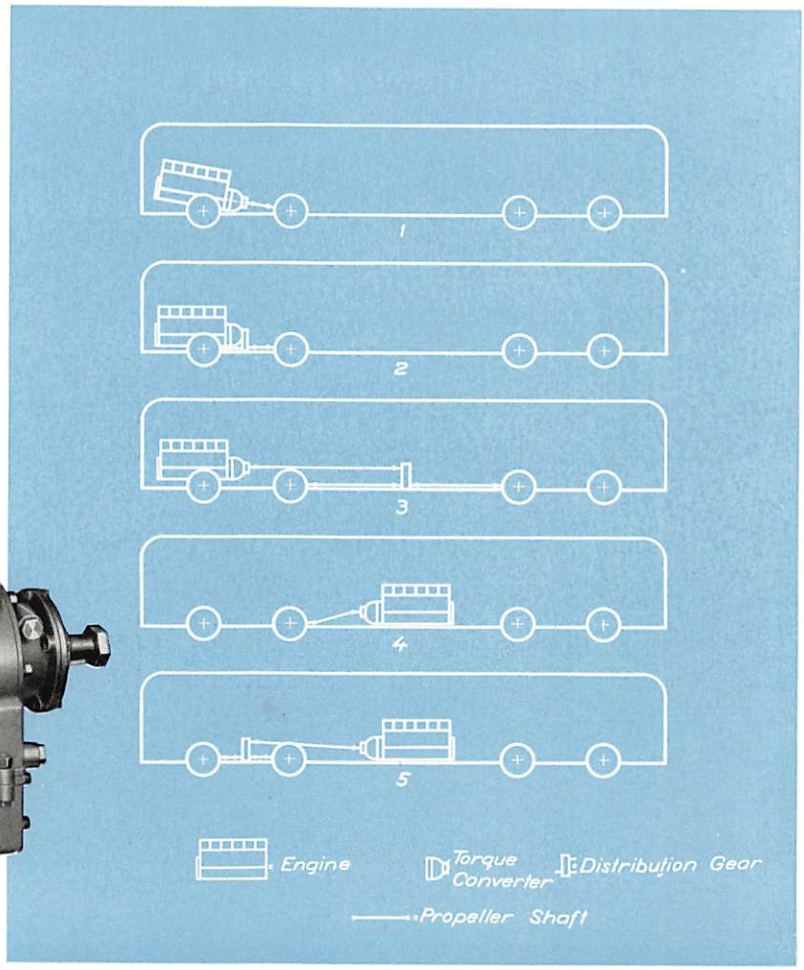
The converter clutch is generally controlled pneumatically or electro-pneumatically by a switch on the driver's control board. An air cylinder is mounted on the clutch housing containing two pistons, one for direct drive and one for hydraulic drive. When no air is admitted the clutch lever is kept in its neutral position



A 150 h. p. Diesel engined rail-car provided with an Atlas Diesel Torque Converter. This car belongs to the Swedish State Railways.

The Atlas Diesel Direct Drive Converter.





Various methods of installing engine and torque converter in a rail-car.

by springs. The action of the pneumatic control apparatus is very soft so that the engagement of the direct drive can hardly be noticed even if the engine speed should not synchronise exactly. For multiple installations the Atlas Diesel Torque Converter can be supplied with an extra freewheel on the output shaft which simplifies the engagement of the direct drive and is recommended for such installations.

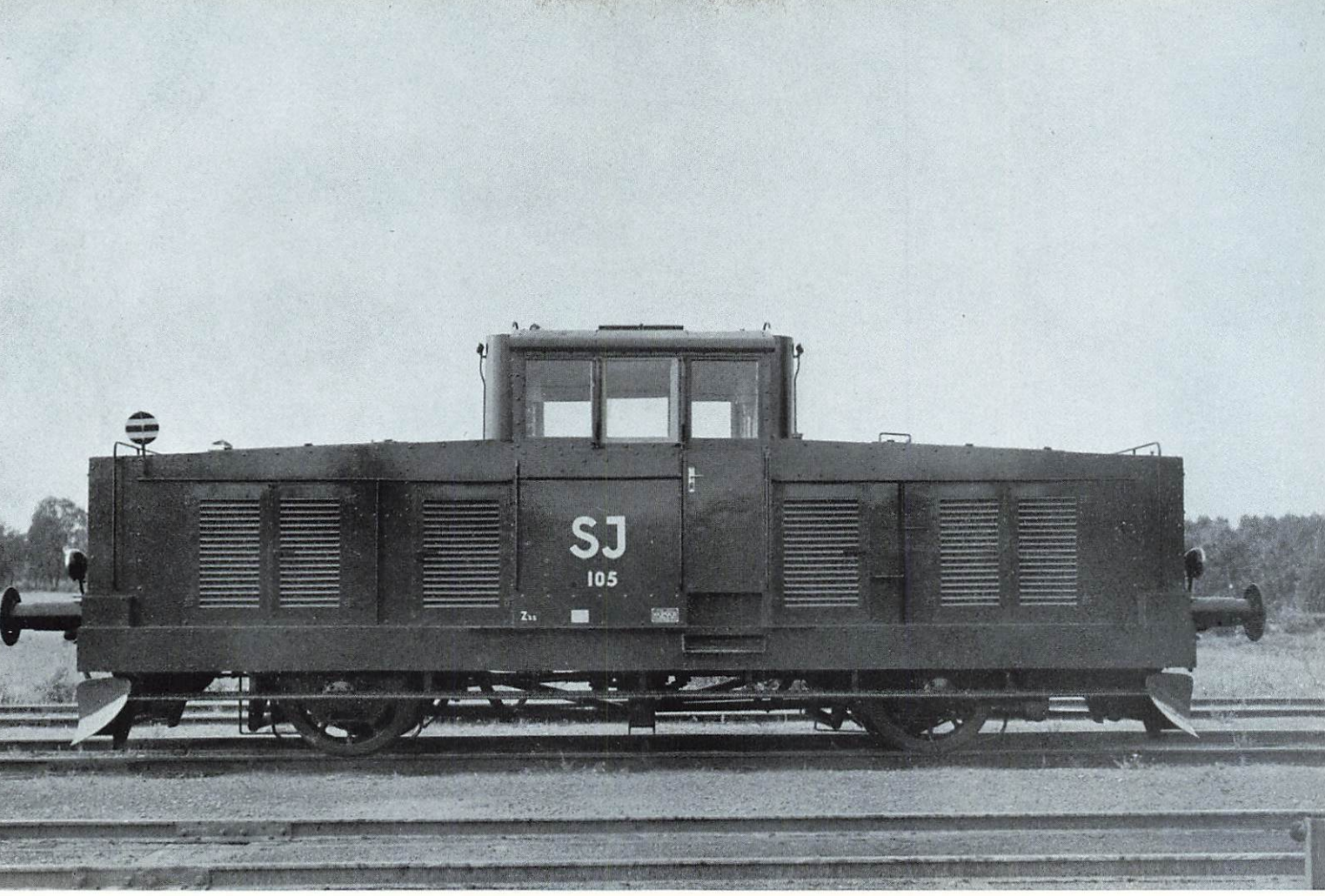
The Atlas Diesel Torque Converter is the ideal transmission for multiple unit trains as any number of torque converters can be simultaneously controlled from one control board by means of electro-pneumatic control.

The above diagrammatic installation drawings show various methods of installing the engine and torque converter in a rail-car.

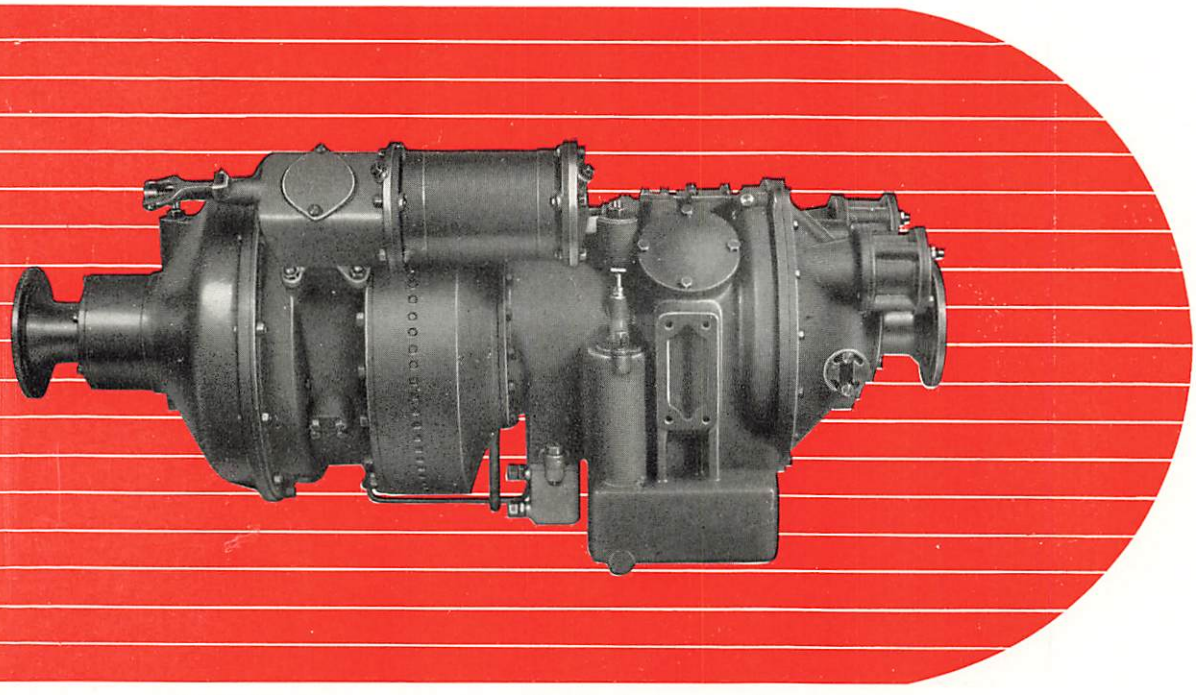
How to drive with a direct drive converter

The engine is started with the clutch control lever in central position. To start the vehicle the control lever is brought into the hydraulic drive position and the brakes are released. The torque transmitted at idling speed by the hydraulic drive is generally sufficient just to move the vehicle on the level. To get maximum acceleration the engine control is moved into the full engine speed position. When the speed of the vehicle reaches about 70 % of the maximum the clutch control lever is switched over into the direct drive position and the engine speed at the same time slightly reduced. The vehicle speed is then controlled by means of the engine accelerator in the usual way. When the vehicle approaches a stopping place the clutch lever is brought back to the hydraulic drive position and the vehicle is brought to rest under the control of the brakes. For stops of short duration the clutch may remain in the hydraulic drive position and to restart, the driver merely releases the brakes and accelerates the engine.

A 400 h. p. double-engined rail-car fitted with Atlas Diesel Torque Converters. This car belongs to the Norwegian State Railways.

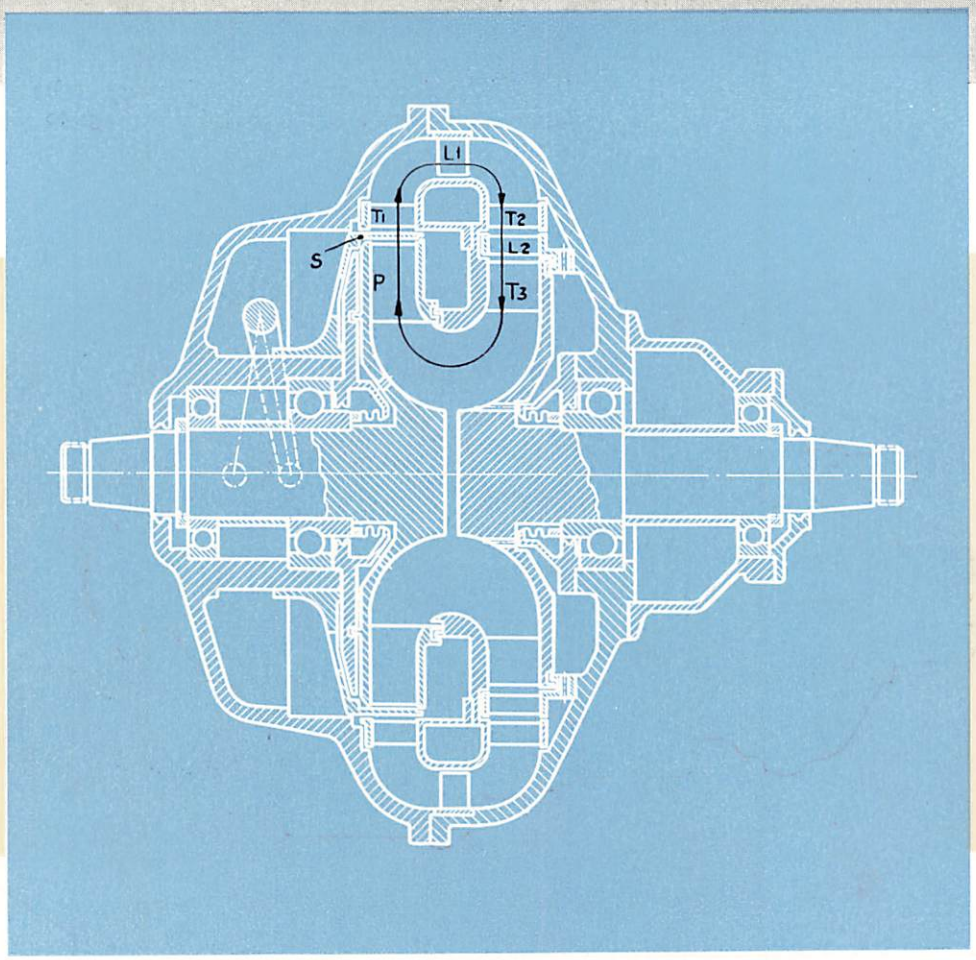


A 300 h. p. double-engined shunting locomotive equipped with Atlas Diesel Torque Converters. This locomotive belongs to the Swedish State Railways.



Hydraulic torque converter with direct drive and step up planetary gear installed in the rail-car illustrated on page 18.

A 600 h. p. double-engined locomotive provided with Atlas Diesel Torque Converters.



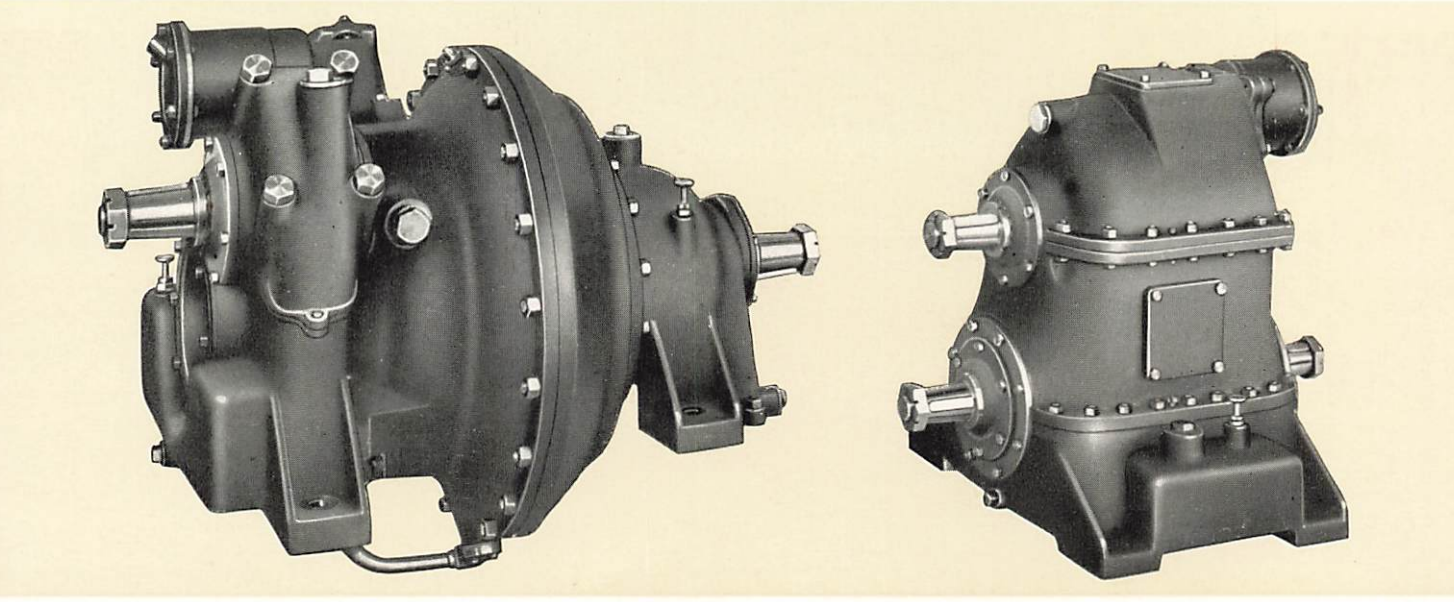
Section of a Ring Valve Torque Converter.

The ring valve torque converter

The ring valve torque converter diagrammatically illustrated on *page 20* consists of a plain converter as described in the beginning of this catalogue but provided with a pneumatically operated ring valve (S). When this ring valve is in the position indicated in the illustration the fluid stream from the converter pump to the turbine is cut off and no torque transmitted to the output shaft. At the same time the engine runs with no load. When the ring valve is withdrawn into a recess in the turbine casing, the fluid circulation is restored and torque will be transmitted to the output shaft in the normal way.

The ring valve torque converter is particularly suitable for heavy vehicles when direct drive for any reason is not desirable. This type of torque converter constitutes the most simple and reliable transmission obtainable.

The ring valve torque converter has a torque speed range which in most cases covers the demands for traction work. In some cases when an extremely large starting tractive effort is required, in combination with a high top speed of the vehicle, the ring valve type torque converter may be combined with an auxiliary two speed mechanical gear box. The control of the combined unit could be arranged in a very attractive way.



Ring Valve Torque Converter with pneumatically operated two-stage auxiliary gear and reverse gear installed in the locomotive illustrated on page 20.

Atlas Diesel Hydraulic Torque Converters are installed in a considerable number of buses, rail-cars and locomotives. The illustrations on these pages show two 250 h.p. double-engined rail-cars both fitted with Atlas Diesel Torque Converters. They belong to private Swedish railways.


3
BJ
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Atlas Diesel AD

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