Automatic transmissions for buses

VOITH

Voith-DIWA® Transmission Type D 506

Fully automatic driving

VOITH automatic

Application

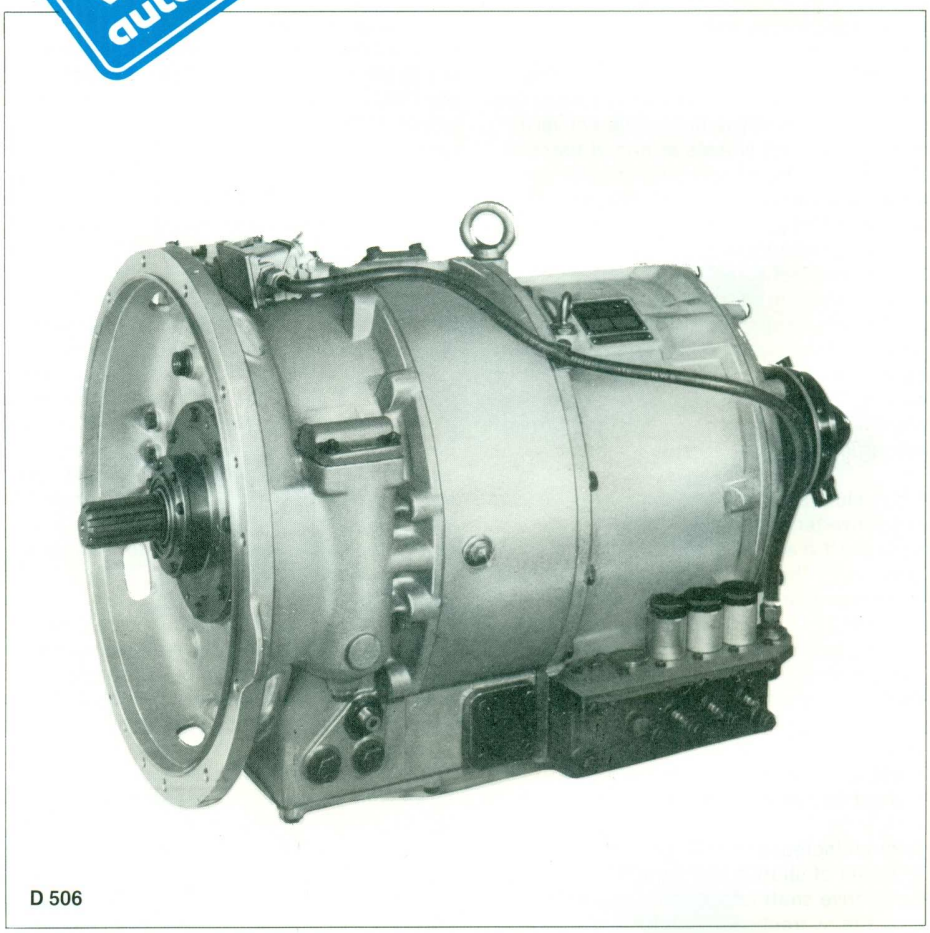
The Voith DIWA® transmission type D 506 is primarily installed in city and suburban buses. It can also be employed, however, in short-distance comercial vehicles, shunting and mining locomotives, light-weight rail-cars, and special purpose vehicles.

Advantages

- Simplicity of operation: no clutch operation or gear changing even when starting and stopping
- Increased safety in traffic
- Smooth and rapid acceleration even on gradients
- No interruption of tractive effort during operation
- Automatic matching of overall transmission ratio to road resistance
- High average speeds over all distances, thus savings in time
- Optimum exploitation of economical engine speed range
- Automatic change-speed mechanism can be over-ridden by manual control
- Stalling of the engine not possible
- Owing to the split-power principle, a low fuel consumption for this type of transmission is obtained
- Vibration and shock absorbing effect of the hydrodynamic converter guaranteeing longer service life of engine and power transmitting components
- Choice of appropriate transmission version allows optimum matching to prevailing operating conditions
- Simple construction permits servicing and repairs to be undertaken by owner's workshop personnel

Principle

The Voith DIWA® transmission type D 506 is a fully automatic hydrodynamic-mechanical transmission; positioned in front of the hydrodynamic torque converter is a differential gear unit which has the function of distributing the flow of mechanical input power. The torque converter and differential gear unit together form the differential-converter unit (= DIWA). Adjacent and to the rear of the differential-converter unit is an epicyclic gearbox equipped with multi-disc brakes for the selection of the forward and reverse gears.



D 506

At lower speeds, the differential gear unit distributes the power transmitted from the engine between one hydraulic power channel and one mechanical channel, whereby the power quota transmitted into the hydraulic channel diminishes progressively with increasing road speed. With this power division, the DIWA® transmission efficiency is considerably higher than that of transmissions whose torque converters transmit the total power input at low road speeds. In this differential-converter transmission, the inherent advantages of a hydrodynamic torque converter — high starting tractive effort, smooth acceleration, automatic matching to load — are exploited to the full in both starting range and at low speeds with maximum economy. At higher speeds, the input power is transmitted purely mechanically. In the mechanical operating range, therefore, the Voith DIWA® transmission has the same negligible transmission losses as any mechanical change-speed gearbox.

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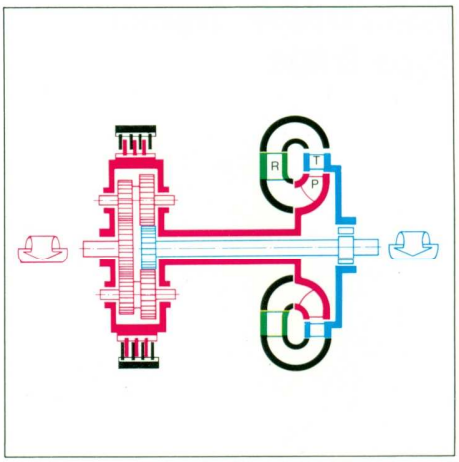
Design and Operation

Fig. 1: Principle of the differential-converter
For explanation of letter symbols, see section "Mode of Operation" or legend to fig. 3



Differential torque converter
As its name suggests, the differential torque converter unit consists of one differential gear unit and one hydrodynamic torque converter. The hydrodynamic torque converter has three bladed wheels arranged together in a common housing: pump impeller, turbine wheel and guide wheel (reaction member). The pump impeller accelerates the operating medium (oil) whose passage of flow is then deflected by the blades of the turbine wheel in varying degrees according to the rotational speed of the latter. In this way, an infinitely variable torque dependent upon turbine speed is applied to the output drive shaft. When the turbine wheel is stationary, the output torque is at its greatest; it diminishes as turbine speed increases.

Fig. 1 illustrates the principle of the differential converter. When the vehicle is at rest, both shaft *b* and output drive sun gear *r* are stationary. The engine drives shaft *a* with input sun gear *s*, and thus pump impeller *P* of converter *C*, via the planet gears *p* and planet carrier *q* of the differential gear *b* at approximately double the engine speed (hydraulic power channel). The engine is thereby loaded to such an extent that at full throttle it is lugged down to 60–65% of its rated speed, and thus into the range of highest torque and lowest fuel consumption.

With an increase of road speed, i.e. increase of speed of shaft *b*, the gear ratio between input drive shaft and pump impeller *P* — and thus the hydraulically transmitted power quota — decreases, while the mechanical power quota transmitted via sunwheel *r* and engine speed both increase.

With increasing engine speed, the converter pump impeller becomes automatically arrested by the differential gear lamellar brake *d*. The turbine wheel *T* also ceases to rotate after having been disengaged from shaft *b* via the freewheel *f*. The hydraulic power channel is now fully interrupted.

Entire transmission
Figs. 3.1 (Version J + BR) and 3.2 (Version U + S) are longitudinal sectional diagrams of the DIWA® D 506 transmissions. Positioned ahead of the differential torque converter unit (differential gear unit *B* with torque converter *C)* is a flexible slip clutch *A* designed to absorb vibrations emanating from the engine and to limit the amount of torque transmitted.

The epicyclic gearbox *D* consists of either two or three planetary gear sets of different ratios for one or two forward speed ranges and one reverse. The planetary gears, which transmit the torque of shaft *b* to output drive shaft *c*, are shifted without any break in the flow of power by means of hydraulically-actuated lamellar gear brakes. A single control piston actuated by the pressure from control pump *i* releases the automatic changeover from the hydraulic to the mechanical operating range.

The hydraulic and mechanical power channels are operative in either high or low speed ranges. A shift of forward speed range is also possible while on the move without any essential interruption of tractive effort.

The automatic changing-up and changing-down with increasing or decreasing road speed respectively can, according to operating conditions, be brought about earlier or later via the accelerator pedal. Moreover, by pressing the accelerator pedal past the full throttle setting into the kick-down position, the driver can either retain the hydraulic operating range with its greater tractive effort up to approx. 60% of the respective maximum speed (high range or low range) or can return to it after change-up. Where an additional changeover-lock is fitted, the driver is able to prevent a change-up into the mechanical operating range.

Controls
The transmission speed ranges are engaged by push-button switches which control the solenoids actuating the multi-disc brakes. The engine brake is automatically switched off when the transmission changes back into the hydraulic operating range.

With the throttle-responsive automatic system, the mechanical operating range extends down to 25% of the maximum speed of the gear engaged.

Cooling
With water-cooled engines, a water jacket surrounding the torque converter is drawn into the engine cooling water circuit, thus normally eliminating the necessity of a larger radiator. Under especially arduous operating conditions, or when in service in countries with high mean ambient temperatures, the transmission is equipped with a supplementary oil cooler.

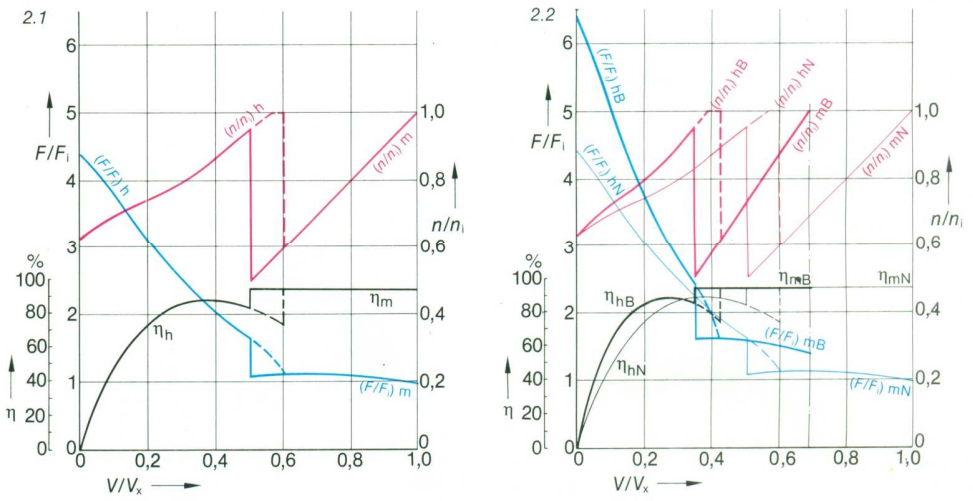
With air-cooled engines, the heat from the transmission oil is dissipated through an air-cooled oil cooler installed separately in the vehicle.

Installation
The DIWA® transmission type D 506 can either be bolted to the engine flywheel housing or installed in some detached position in the vehicle chassis. For the flange-fitting of the transmission to the engine, an adaptor housing is usually necessary whose form is dependent upon engine type.

Performance Diagram

Fig. 2.1: transmission version U + S
Bild 2.2: transmission version J + BR

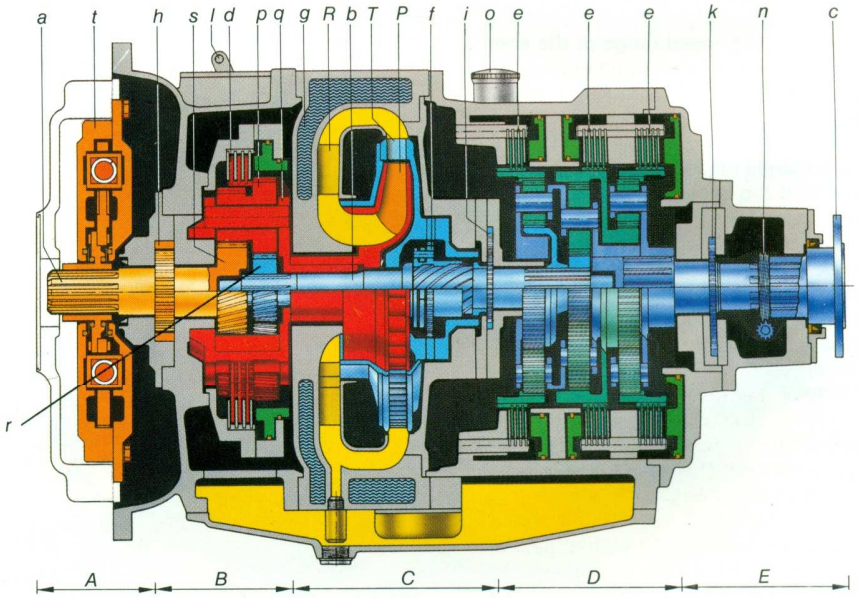
F Tractive effort
F_i Ideal tractive effort at η = 1, rated power at transmission input, and V_x
n Engine speed
n_i Engine rated speed
η Efficiency
V Road speed
V_x Max. road speed
Index h:
hydro-mechanical channel
Index m:
mechanical channel
Index N:
High speed range
Index B:
Low speed range

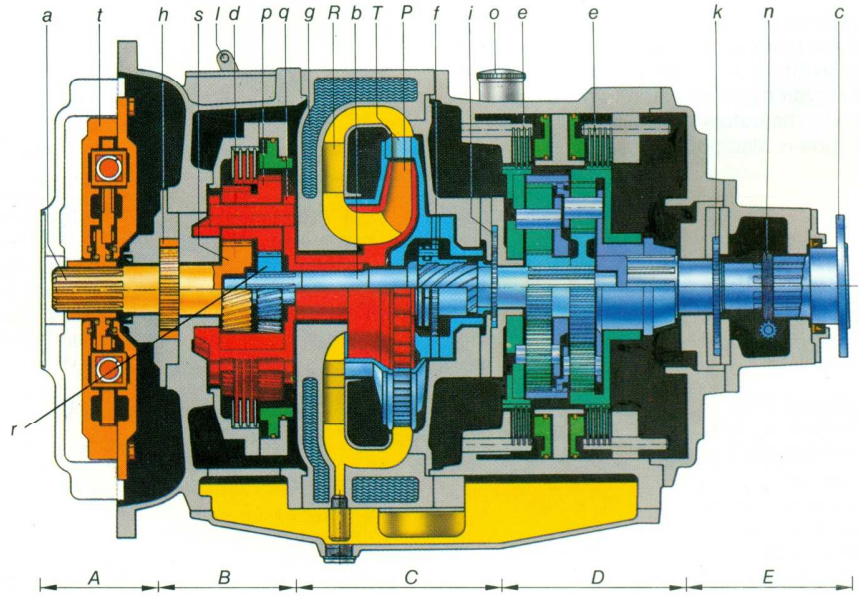


Longitudinal sectional diagram of differential-converter transmission type D 506

Fig. 3.1: Version J + BR (above)
Fig. 3.2: Version U + S (below)

A Slip clutch
B Differential gear unit
C Hydrodynamic torque converter
D Epicyclic final drive gearbox
E Output drive
P Pump impeller
T Turbine wheel
R Reaction member (Guide wheel)
a Input drive shaft
b Intermediate shaft
c Output drive shaft
d Distributor gear brake
e Final drive gearbox brakes
f Freewheel
g Cooling water jacket
h Operating pump
i Control pump
k Output drive pump
l Control lever
n Speedo drive
o Oil filler neck
p Planet gears
q Planet carrier
r Sun gear output drive
s Sun gear input drive
t Torsions damper





Where performance counts...

VOITH

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Versions
The design of the Voith DIWA® transmission type D 506 can be precisely matched to prevailing operating conditions.

1. The power and speed range of the engine can be exploited to an optimum by appropriate choice of torque converter size.

2. The demands made upon a vehicle in respect of top speed, acceleration, hill-climbing ability, and braking power can be fulfilled to an optimum by aproppriate choice of final drive planetary gears sets. This option also has the advantage that, for light duty purposes, a simple and thus favourably priced (e.g. with only one forward speed range) transmission may be employed. See table of ratios.

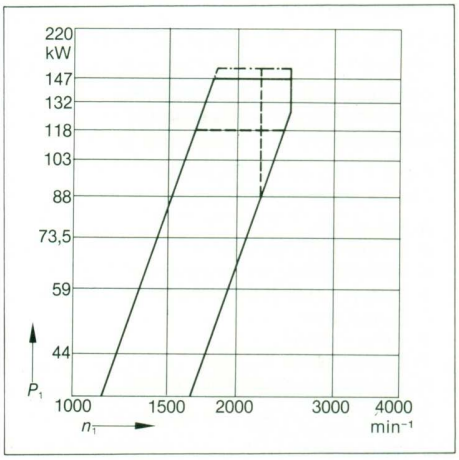
3. The transmission is available with an automatic system either dependent upon or independet of engine throttle setting. Transmissions with automatic systems dependent upon throttle setting are primarily employed where the engine brake is to be effective over the largest speed range possible.

4. Matching drive flanges are available for normal types of cardan shaft. The direct flange-fitting of further equipment, such as a hydrodynamic brake or transfer gearbox, to the output drive side of the transmission is also possible.

Fig. 4: Performance range of Voith DIWA® transmission D 506

– – – – *Peak input speed 2200 rpm for version JSR and JBR*
— — — *118 kW (160 hp) limit for installation in rail vehicles*
—·—·— *For powers in this range, consult Voith*

P_1 = *Transmission input power*
n_1 = *Transmission input speed*



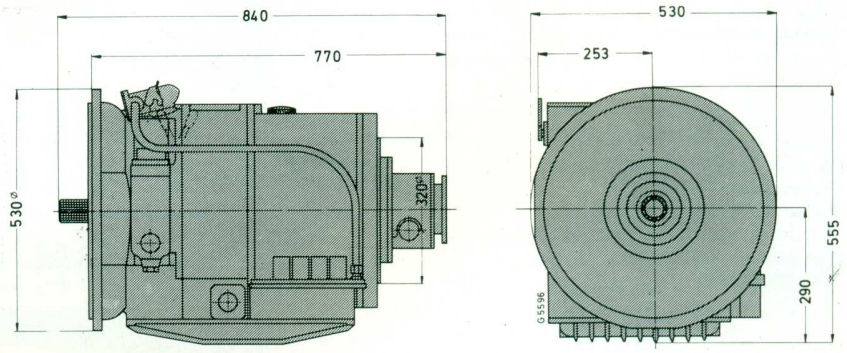


Fig. 5:
Principal dimensions in mm

Technical Data

Maximum input torque	80 kpm
Maximum input power	162 kW (220 hp)
Power range	see fig. 4
Maximum input speed	2500 rpm
Peak input speed for version JSR + JBR	2200 rpm
Ratios and weights — see table	

Gear Ratios and Weights

Transmission version		U + S	J + BR	JBR	JSR
Ratios in mechanical operating range	high speed range		1,36	0,95	0,85
	low speed range	1,46	1,97	1,97	1,39
	reverse gear	−1,46	−1,93	−1,93	−0,96
Weight approx.		236 kp	254 kp	254 kp	254 kp
Oil capacity	approx. 18 litres of Voith-approved HD engine oil SAE 10				