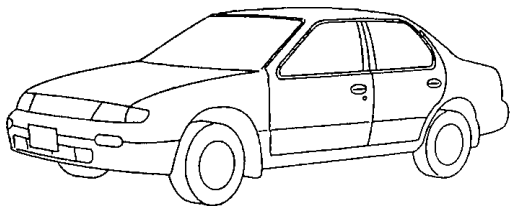
HARDTOP

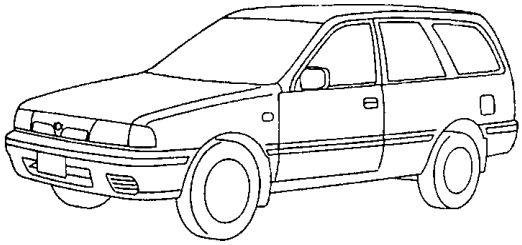
A vehicle with no center pillar and no door sash (window frame). This vehicle offers a wide view, and the image of design is nimble. The style with center pillars but with no sash is called the “pillared hardtop”.



TCH013

VAN

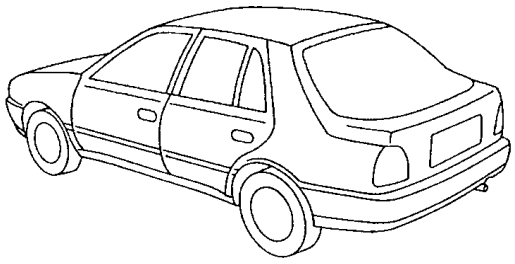
This is a commercial car with a box-type baggage compartment at the rear of the cab.



TCH014

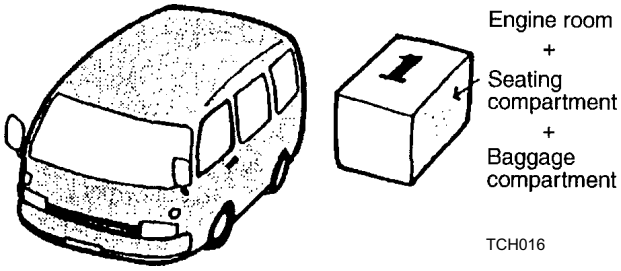
HATCHBACK

The vehicle whose rear door can be lifted up like a hatch of a ship. This style can be seen in many 2-box cars.

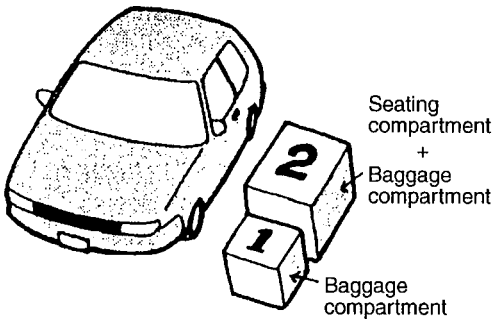


TCH015

BODY TYPES-2

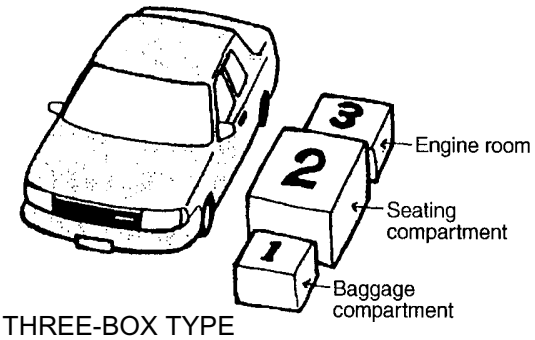


ONE-BOX TYPE



TWO-BOX TYPE

TCH017



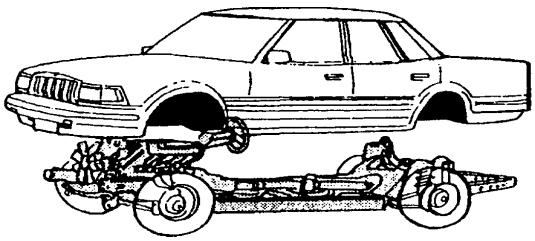
THREE-BOX TYPE

TCH018

3-2. BODY CONSTRUCTION

1. FRAME CONSTRUCTION

In the frame construction, the body is mounted on a ladder like frame. Because this construction is strong but heavy, this construction is suitable mainly for the truck body.

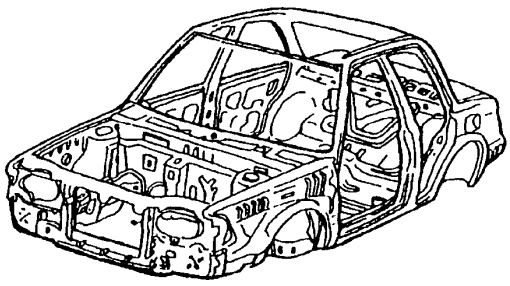


TCH019

2. MONOCOQUE CONSTRUCTION

A flat plate is easily bent by an outside force. However, by making the plate into a shape of the letter L or by processing it into the shape of a box, the strength is significantly improved. This principle is used for this construction.

- Light in weight because no frame is provided.
- An engine and suspension system are mounted to the body directly.



TCH020

DRIVE TRAIN

1. OUTLINE OF THE DRIVE TRAIN

1-1. DESCRIPTION

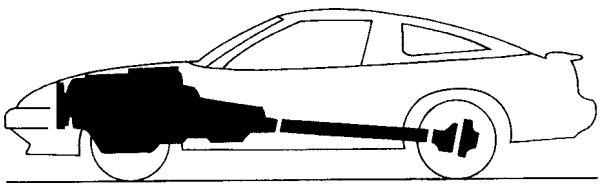
The drive train transmits torque to rotate the wheels. The drive train consists of the following.

- **CLUTCH** ... Transmits or cuts engine torque to the transmission.
- **TRANSMISSION** ... Depending upon driving conditions, the transmission changes the gear ratio, the amount of torque from the engine, and the forward or reverse direction of the vehicle.
- **PROPELLER SHAFT & UNIVERSAL JOINT** ... Transmits engine torque from the transmission to the final drive (FR vehicles). Universal joints are generally connected to both ends of the propeller shaft. These joints ensure smooth movement even when the transmission and final drive are at the greatest or smallest distance from each other.
- **FINAL GEAR** ... At the same time that torque from the propeller shaft (or transmission) is being transferred to the axle shaft (or drive shaft), the final drive enables final speed reduction and increases tractability.
- **DIFFERENTIAL CARRIER (FINAL DRIVE)** ... Creates rotation variation between the left and right wheels to allow for smooth travel on rough roads or when making turns.
- **DRIVE SHAFT** ... Transmits torque from the final drive to the wheels. Has the same function as the propeller shaft. (All FF vehicles have drive shafts. Only FR vehicles with independent suspension have drive shafts.)

1-2. OUTLINE OF DRIVE TRAIN

(1) FRONT ENGINE REAR DRIVE (FR = Front Engine, Rear Drive)

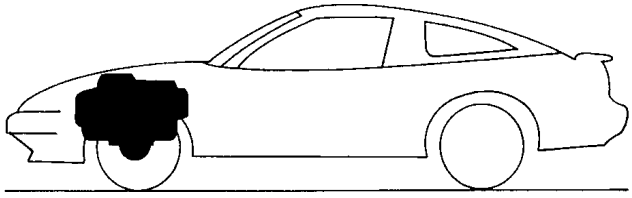
The engine, clutch, and transmission, and other parts are placed as an integrated unit in the front of the vehicle while other parts such as the differential carrier are placed in the rear. The front and rear units are connected by a propeller shaft.



TCH021

(2) FRONT ENGINE FRONT DRIVE (FF = Front Engine, Front Drive)

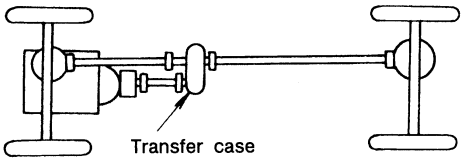
The engine, clutch, transmission, final drive and other parts are placed as an integrated unit in the front of the vehicle making the propeller shaft unnecessary.



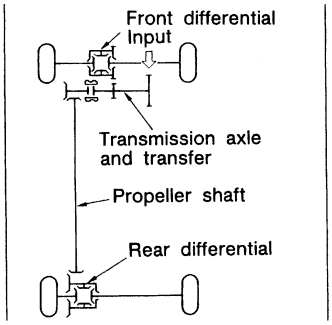
TCH022

(3) FRONT ENGINE 4-WHEEL DRIVE (4WD = Wheel Drive)

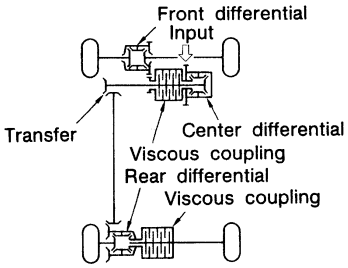
As shown in the figure, drive torque is distributed to each of the wheels. A transfer assembly is used to distribute the torque. There are both full-time 4WD) vehicles and part-time 4WD) vehicles.



TCH023



TCH024



TCH025

(a) Part-time 4WD

This allows the driver to use the 2WD mode or the 4WD mode as desired. On FF vehicles, for example, moving between 2WD and 4WD can be accomplished by transferring the engine torque through the clutch, converter, transmission, and final gear to the transfer. Most vehicle use an electric (switch operated) system.

(b) Full-time 4WD (Permanent 4WD)

With this type, the 4WD mode operates at all times. A viscous coupling is installed behind the transfer which allows flexible transfer of torque so that when the load over the front wheels suddenly decreases, torque will be continually provided tot he rear wheels preventing the front t wheels from loosing traction.

(4) REAR ENGINE REAR DRIVE (RR = Rear Engine, Rear Drive)

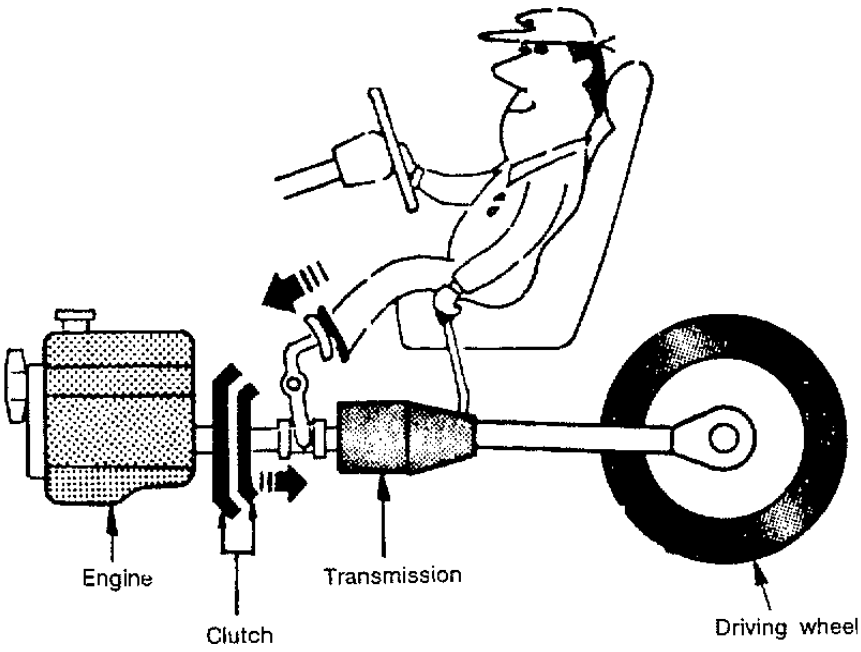
The engine is placed behind the rear wheels, and drives the rear wheels.

(5) MIDSHIP (MR)

The engine is placed between the front and rear wheels, and drives the rear wheels.

2. CLUTCH

2-1. FUNCTION OF THE CLUTCH



TCL001

A clutch used in vehicles transmits the torque from the engine to the transmission/ axle. Its purpose is to disconnect the engine from the transmission when starting the engine, or when shifting gears, and to reconnect the engine to the transmission for driving the vehicle. This reconnection or engagement of the engine and drive line must be done smoothly to ensure smooth starting and driving of the vehicle. To achieve these objectives, the clutch must satisfy the following requirements:

- In the engaged state, the clutch must transmit engine power to the transmission without slipping.
- At the beginning of engagement, the clutch must have a proper amount of slip so that the vehicle can start off without jerking.
- The engaging and disengaging of power must be done quickly when shifting gears.

3. TRANSMISSION (FR models) /TRANSAXLE (FF models)

3-1. FUNCTION OF THE TRANSMISSION

An automobile requires a great amount of driving force for starting, accelerating, climbing hills, or carrying heavy load: however, when running on a highway at high speed, it needs fast rotation of the wheels rather than a large driving force. Also requires such a device should be able to reverse the direction of rotation so that the vehicle can also be operated in reverse. This device is called the transmission. Multiplication of torque is performed by reducing the rotating speed. This is attained by changing the engagement pattern of gears in the transmission.

(1) TRANSMISSION GEAR RATIO AND TORQUE CHANGING

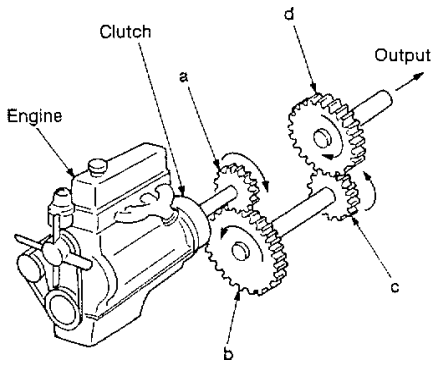
The transmission consists of several gears which can mesh in various ways to adjust torque and speed.

- **Power transmission line**

gear a _ gear b → gear c → gear d.

- **Torque, gear ratio and transmission gear ratio**

When starting to accelerating or climbing up, the first gear (the smallest drive gear in the transmission) or the second gear is used. Torque is increased by smaller gear rotating larger gear (the reason described later), though, the rotation of the output shaft is slowed and speed is decreased. The torque change relates to gear ratio. The calculation of gear ratio is as follows.



TRANSMISSION OPERATION PRINCIPLE

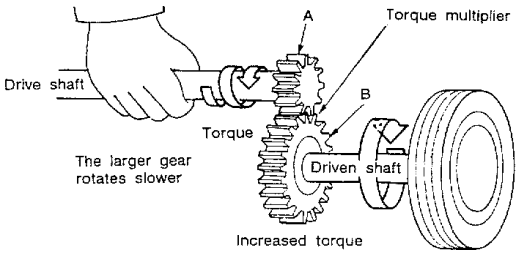
TMT001

$$\text{Gear ratio} = \frac{\text{Number of teeth of driven gear}}{\text{Number of teeth of drive gear}}$$

Transmission has several different number of teeth gears. Transmission gear ratio can be changed due to the combination of gears. Transmission torque relates transmission gear ratio. The calculation of transmission gear ratio is as follows.

$$\text{Transmission gear ratio} = \frac{\text{Number of teeth of driven gear b}}{\text{Number of teeth of drive gear a}} \times \frac{\text{gear d}}{\text{gear c}}$$

The relation among transmission gear ratio, torque and speed is as follows. When transmission gear ratio is 3, the output torque comes to 3 times of input torque, and output shaft speed comes to one third. In a gear system ' a reduction of speed means an increase in the torque transmitted.

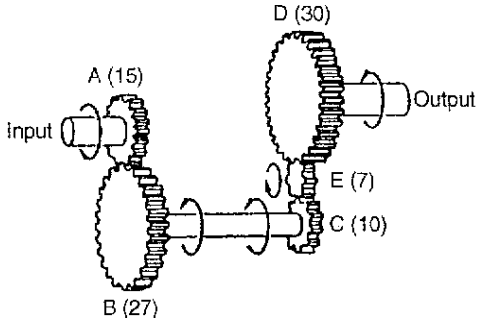


PRINCIPLE OF TORQUE INCREASE

TMT002

(2) IDLER GEAR AND REVERSE

The gear system shown in the figure is similar in structure to the previous figure with the exception that an idler gear E, has been added between C and D. Movement occurs in the order of. input - A -B - C - E - D - output. As the figure shows, the rotation direction of the output shaft is different. In other words, the idler gear is used to reverse the direction of the shaft. As shown below, the gear ratio with idler gear is the same as that of without idler gear, it can be seen that the idle gear has no effect on the transmission gear ratio.



Combination of gear teeth (reverse)

TMT003

[With idle gear]

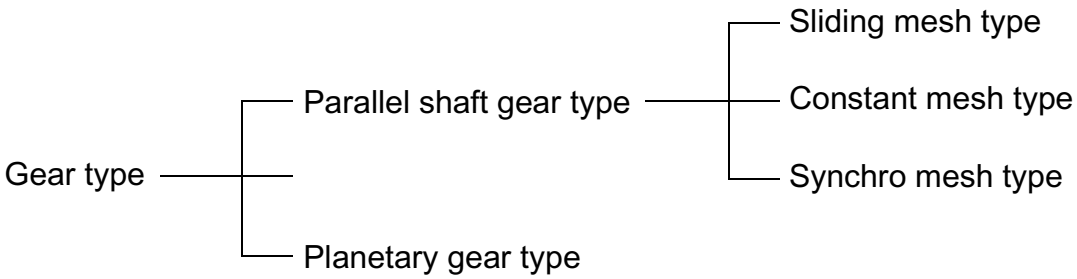
$$\frac{\text{B teeth (25)}}{\text{A teeth (15)}} \times \frac{\text{E teeth (7)}}{\text{C teeth (10)}} \times \frac{\text{D teeth (30)}}{\text{E teeth (7)}} = 5$$

[Without idle gear]

$$\frac{\text{B teeth (25)}}{\text{A teeth (15)}} \times \frac{\text{D teeth (30)}}{\text{C teeth (10)}} = 5$$

3-2. TRANSMISSION TYPES

Transmissions can be broadly divided into the categories shown below, but the major types in use today are the synchromesh type in the parallel shaft gear category and the planetary gear type. The parallel shaft gear type has two shafts with several groups of gears which change position as required. In most such gear types, forward motion is generated by a combination of four or five gears while reverse is usually generated by one gear. The planetary gear type is often used in automatic transmissions because it allows for easy control of automatic shifting.

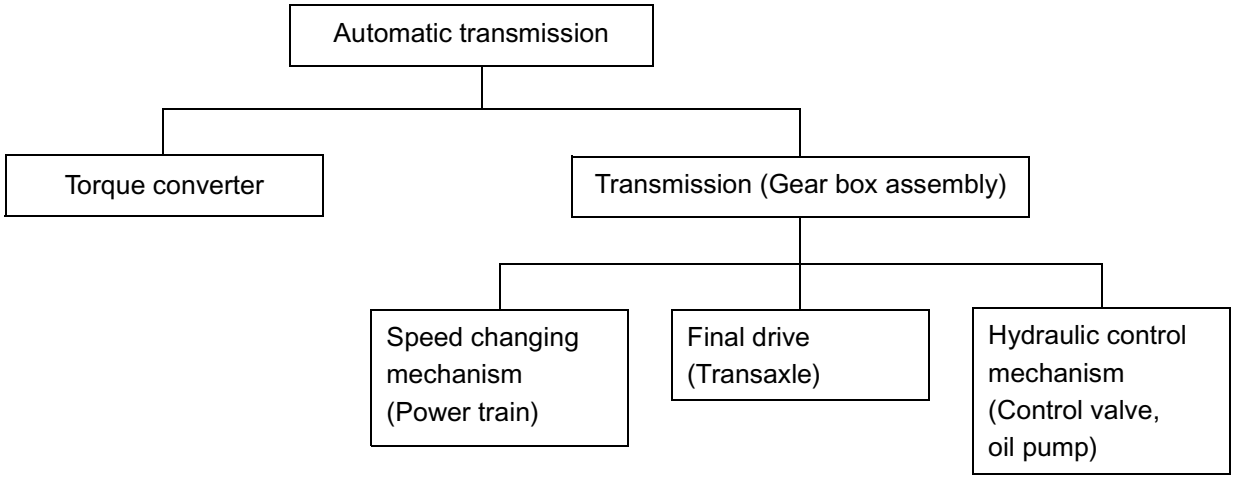


Currently, most manual transmissions use the parallel shaft gear type. Most automatic transmissions use the planetary gear type with a torque converter.

3-3. AUTOMATIC TRANSMISSION

(1) DESCRIPTION

The major parts of the automatic transmission include the cases and housings, torque converter which transmits power, hydraulic control mechanisms, shift control mechanisms and auxiliary devices. The hydraulic devices, which include control valves, drive the power train and the power train includes the torque converter, clutch & brake, planetary gear, output shaft, final drive, etc.
The shift control mechanisms work by sending instructions to the hydraulic control mechanisms.



The torque converter transmits the revolving power of the engine to the output shaft by means of hydraulic oil called automatic transmission fluid (role of the fluid coupling). Also, the torque converter works to enhance the torque transmitted to the output shaft depending on the driving conditions in a stepless manner from 1:1 to 1:2 (role of the stepless transmission up to a gear ratio of 1:2).

Planetary gears are used for the speed changing mechanism and they change the rotation transmitted from the torque converter to preset gear ratios. The hydraulic control mechanism directs the hydraulic pressure generated in the oil pump to each hydraulic cylinder (clutch and servo) based on vehicle speed and load. Also, it automatically fixes or releases each gear of the planetary gear to perform automatic speed changes.

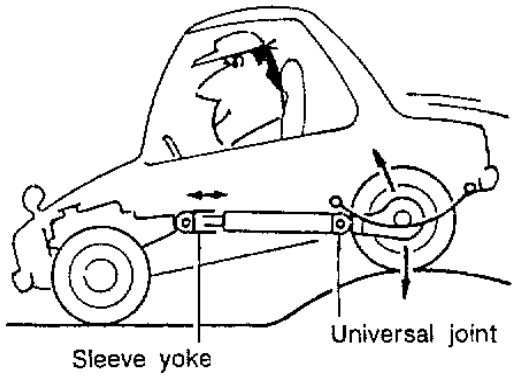
As described above, the torque converter itself functions to enhance torque and change speeds. Nevertheless, a transmission is needed. This is because sufficient driving performance is requested for a vehicle and there is also a need to rotate the power train in reverse. Recently, the transmission has become increasingly multi-staged and complicated.

4. PROPELLER SHAFT & DRIVE SHAFT

4-1. PROPELLER SHAFT

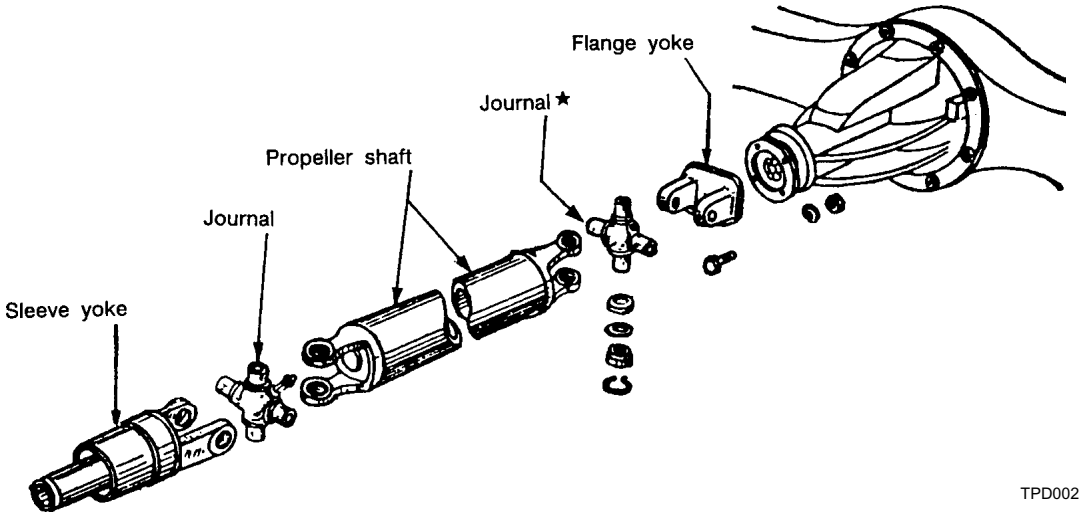
(1) DESCRIPTION

On FR vehicles, a shaft is needed to transmit power from the transmission to the final drive. This is called the propeller shaft. When the vehicle is being driven on uneven roads, the transmission and final drive are always changing positions either vertically or laterally in relation to each other. Because of this continual change, the transmission and final drive cannot be one fixed length or fixed angle.



TPD001

SLEEVE YOKE AND SPLINE

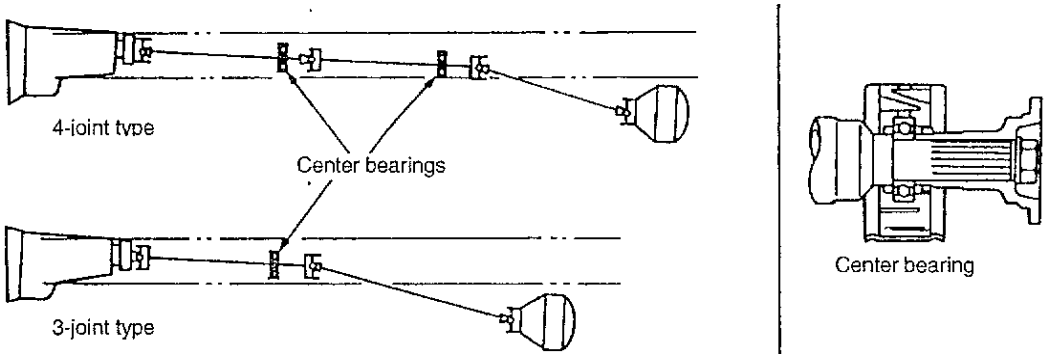


TPD002

*This journal is commonly called either a cross shaft or spider

This is why the propeller shaft is connected with a universal joint and a sleeve yoke so that rotation torque can always be transmitted smoothly from the transmission to the final drive. The universal joint allows for vertical angle changes. The sleeve yoke with spline makes it possible for the shaft to expand or shrink. The propeller shaft is generally light, with strong turning torque. A hollow steel pipe with strong flexural rigidity is used.

The propeller shaft rotates at high speeds when travelling fast. To prevent vibration and loud noise, the propeller shaft must be in complete balance.
On most vehicles, the wheel base is quite short requiring a 2-piece propeller shaft. The use of shafts that are held by a central bearing are becoming more common. The reason a 2-shaft propeller is used is to improve ride comfort at high speeds and to prevent the shaft from being damaged by hard twisting and turning.



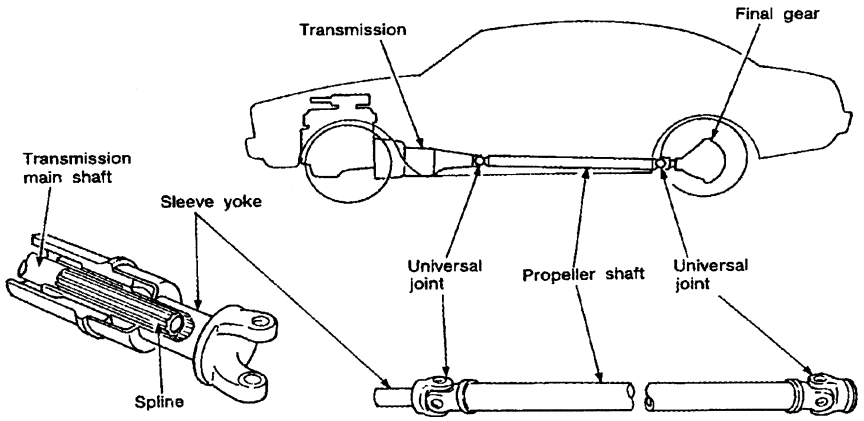
TPD003

CENTRE BEARING

4-2. UNIVERSAL JOINT

(1) DESCRIPTION

A universal joint is general connected to the ends of the propeller shaft. It allows for torque to be transmitted smoothly even when there is a large gap between the transmission and the final gear.
A spline on the propeller shaft allows for the propeller shaft to adjust length without any damage when the wheels move up or down.

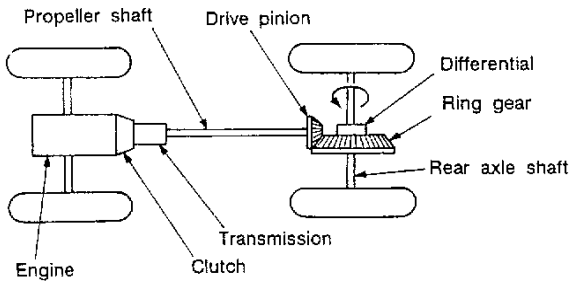


TPD004

UNIVERSAL JOINT

5. FINAL DRIVE

The torque from the engine moves through the transmission and propeller shaft to the final drive. The final drive consists mainly of the final gear assembly (reduction gear) and the differential.



TPD005

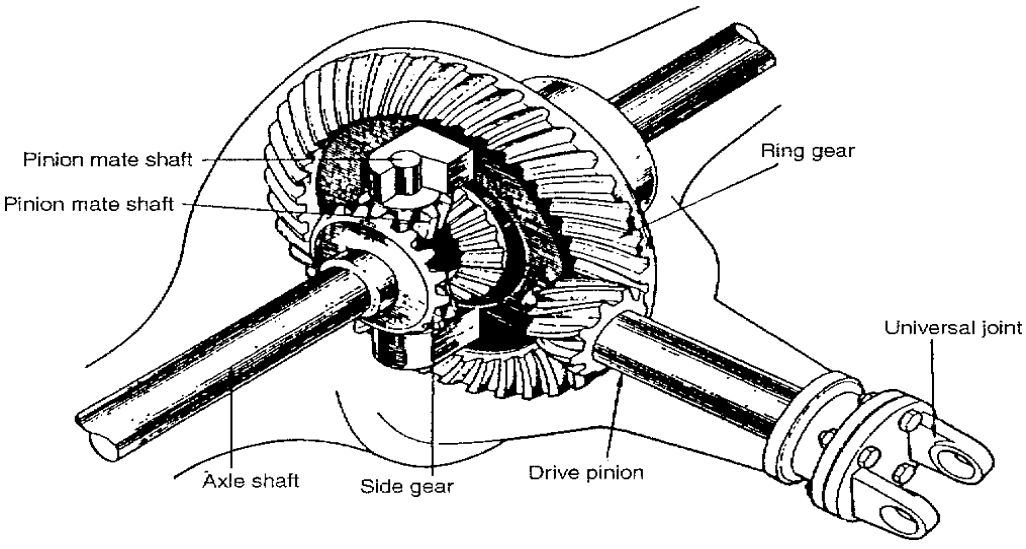
The final gear ultimately reduces the engine speed and delivers increased traction to the wheels. The differential permits both left and right wheels to rotate at different speeds when the vehicle rounds a curve.

5-1. FINAL GEAR

The final gear reduces the engine speed and increases the rotation power for increased torque to the drive shaft. The final gear receives its name because engine power is not reduced any more after the final gear assembly. On FR vehicles, the final gear serves to align the direction of the transmitted torque at right angles. The reduction ratio that the final gear creates differs with each vehicle. The appropriate ratio is determined by a composite of factors which include running resistance. engine output, rotation range, effective tyre radius for maximum speed, acceleration performance, climbing power, and fuel consumption.

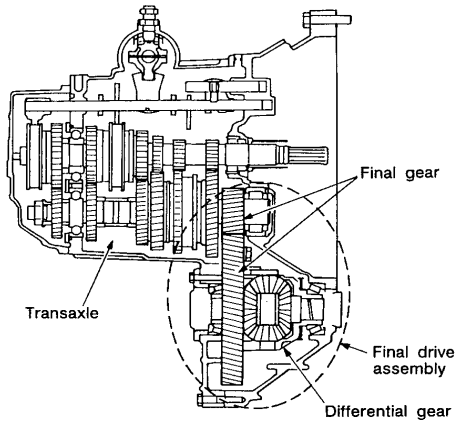
$$\text{Final gear ratio} = \frac{\text{Number of driven ring gear teeth}}{\text{Number of drive pinion teeth}} \quad (\text{Example: } \frac{35}{9} = 3.889)$$

FR VEHICLE FINAL DRIVE ASSEMBLY



TPD006

As shown in the figure, on front-engine drive vehicles, the transaxle, final gear, and differential are one unit that operate as the transaxle.



TPD007

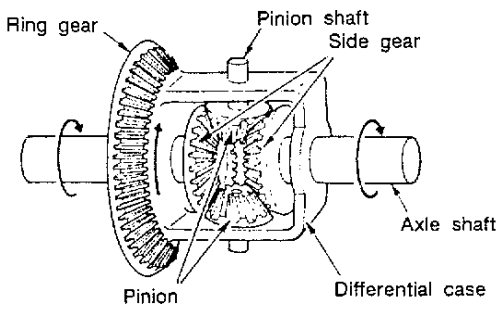
5-2. DIFFERENTIAL GEAR

(1) DESCRIPTION

The differential helps torque to be smoothly transferred from the final gear to the wheels. When the vehicle rounds a curve or when travelling straight on rough roads, the rotation length of the left and right wheels will vary. If the rotation of both sides is the same (both sides rotating on the same shaft), the wheel with the shorter length will slip making driving difficult. So that the wheels do not slip and can rotate smoothly, the differential allows for left and right wheels to rotate at different speeds.

(2) BASIC STRUCTURE AND OPERATION OF THE DIFFERENTIAL

As shown in the figure, the differential pinion inside the differential case is meshed with side gears.
A spline in the centre of the side gears is connected to the axle drive shaft.



TPD008

BASIC STRUCTURE OF THE DIFFERENTIAL

Because the differential case is an integrated part of the ring gear, torque can be transmitted from propeller shaft _ drive pinion → ring gear → differential case → differential pinion side gear → axle (drive) shaft.

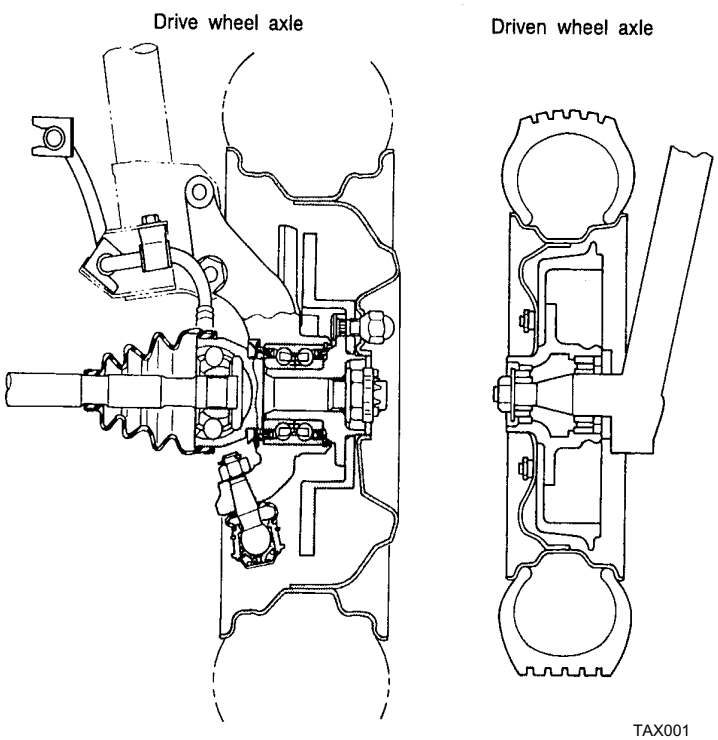
Differential operation
When the vehicle is travelling straight, the differential allows the wheels on both side to rotate together; when travelling around a corner, the differential allows for variation between wheels while transmitting smooth drive torque.

SUSPENSION SYSTEM

1. AXLE

1-1. AXLE TYPES

There are basically two types of axles. The driven wheel axle which simply holds up the weight of the body and the drive wheel axle which, in addition to holding the load of the vehicle, transmits traction.



TAX001

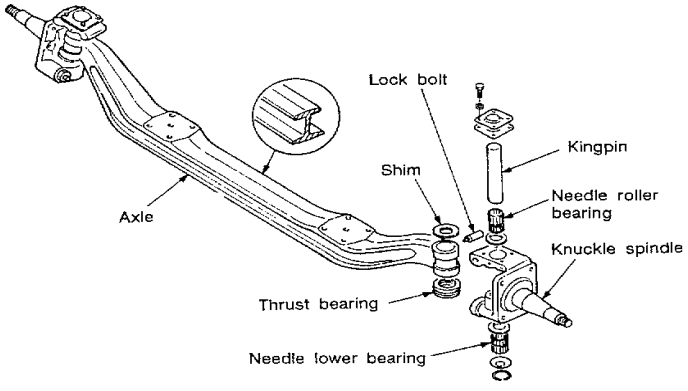
The axle can be further classified by structure into the rigid axle type that is a single shaft connecting the right and left wheels and the independent suspension type axle that allows wheels to move independent of each other.

1-2. FRONT AXLE

The front axle supports the front wheel load and is used to control driving direction. There are two types: the rigid axle type and the independent type.

(1) RIGID AXLE (DRIVEN WHEEL TYPE)

The rigid axle type connects right and left wheels on a single axle. It is strong and large in structure.

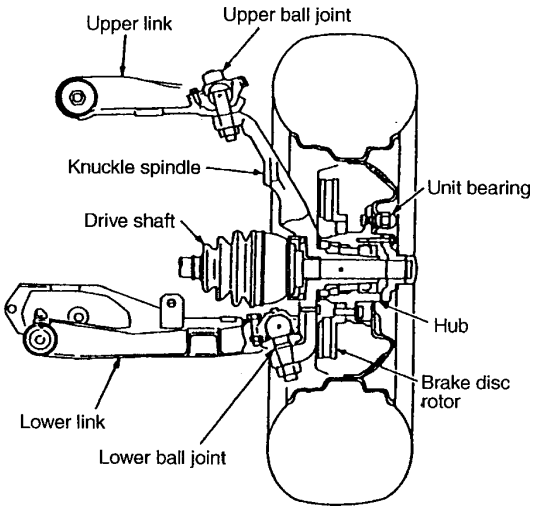


TAX002

This type is simple and reliable and is used for larger commercial vehicles. The body tips very slightly on turns, but because the axle is heavy, the ride can be uncomfortable when one wheel passes over a bump.

(2) INDEPENDENT SUSPENSION (DRIVE WHEEL TYPE)

This type is used for the front axle on FF and FR-4WD vehicles and is usually similar to the structure shown in the illustration. (The front axle in the illustration is the double wishbone type)



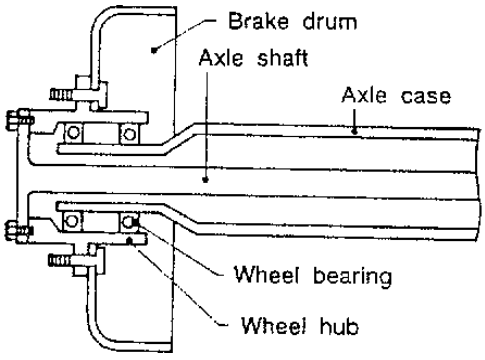
TAX003

1-3. REAR AXLE

The outer part of the rear axle shaft supports the weight of the frame and the body. There are two types: full-floating and semi-floating.

(1) FULL FLOATING TYPE

On this type, the wheel hub is connected by two bearings on the end of a free floating axle case. This means that the entire weight of the body is on the axle case and that torque power is transmitted exclusively by the torque shaft. Because the axle shaft and the case that supports the body weight are separate, this type is used often on large and medium size trucks and buses.



TAX004