Unit IV
Epicyclic gear boxes
Gear train

• It is defined as two or more gears are made to mesh with each other then power is transmitted from one shaft to another.
• The nature of the train used depends upon the velocity ratio and the relative position of the axes of shafts.

Types of gear trains

• Simple gear train
• compound gear train
• reverted gear train
• Epicyclic gear train
Simple gear train
- when there is only one gear on each shaft is called simple gear train

compound gear train
- when there are more than one gear on a shaft is called compound gear train

Reverted gear train
- When the axes of the first gear and the last gear are co-axial then the gear train is known as reverted gear train.

Epicyclic gear train
- The axes of the shafts over which the gears are mounted, may move relative to a fixed axis.
Simple gear train
compound gear train

Fig. 13.2. Compound gear train.
Reverted gear train
Epicyclic gear train
Epicyclic gear train

- Where a gear A and the arm C have a common axis at O₁ about which they can rotate.
- The gear B meshes with gear A and has its axis on the arm O₂, about which the gear B can rotate.
- If the arm is fixed, the gear train is simple and gear A can drive gear B or vice-versa, but if gear A is fixed and the arm is rotated about the axis of gear A, then the gear B is forced to rotate upon and around gear A.
- Such motion is called epicyclic and the gear trains arranged in such a manner that one or more of their members move upon and around another member are known as epicyclic gear train.
Advantages of epicyclic gear

- Planetary gears are in constant mesh so that neither dog-clutches nor sliding gears with (or) without synchromesh devices are employed.
- Gear ratio changes are made with either external contracting band brakes (or) multi-plate clutches of relatively small dimensions.
- The load on the gears is distributed over several gear wheels, instead of only a pair of gears.
- The epicyclic gear train can be made smaller in the overall dimensions than for the 3 (or) 4 speed gear box gears and gear housing.
- As the epicyclic gears work within an annulus (or) ring gear with its external surface of cylindrical form, a more compact unit is obtained, which operates about a common central axis.
Automobile epicyclic gear
<table>
<thead>
<tr>
<th>Mode</th>
<th>Sun</th>
<th>Carrier</th>
<th>Annulus</th>
<th>Gear Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOR HIGH REDUCTION</strong></td>
<td>DRIVER</td>
<td>DRIVEN</td>
<td>FIXED</td>
<td>((A / (A+B)) = 30 / (30 + 75)) \nGear Ratio = 3.5 : 1</td>
</tr>
<tr>
<td><strong>FOR LOW REDUCTION</strong></td>
<td>DRIVEN</td>
<td>DRIVER</td>
<td>FIXED</td>
<td>((B / (A+B)) = 75 / (30 + 75)) \nGear Ratio = 1.4 : 1</td>
</tr>
<tr>
<td><strong>FOR DIRECT DRIVE</strong></td>
<td>DRIVER</td>
<td>CARRIER AND ANNULUS ARE INTER LOCKED WITH EACH OTHER</td>
<td>FIXED</td>
<td>GEAR RATIO = 1 : 1</td>
</tr>
<tr>
<td><strong>FOR OVER DRIVE</strong></td>
<td>FIXED</td>
<td>DRIVER</td>
<td>DRIVEN</td>
<td>((A+B) / B = (30 + 75) / 75) \nGear Ratio = 1 : 1.4</td>
</tr>
<tr>
<td>FOR REVERSE DRIVE</td>
<td>SUN = DRIVER</td>
<td></td>
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<td>------------------</td>
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<tr>
<td></td>
<td>CARRIER = FIXED</td>
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<tr>
<td>ANNULUS = DRIVEN</td>
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<table>
<thead>
<tr>
<th>FOR NEUTRAL</th>
<th>SUN = DRIVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARRIER = FREE</td>
<td></td>
</tr>
<tr>
<td>ANNULUS = DRIVEN</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GEAR RATIO</th>
<th>A / B = 30 / 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEAR RATIO = 2.5 : 1</td>
<td></td>
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</tbody>
</table>

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<tr>
<th>GEAR RATIO</th>
<th>GEAR RATIO = --</th>
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</table>
Wilson gear box
The gearbox comprises of three subassemblies, the running gear, the brake harness and the control mechanism housed in an oil tight container.

This consists of a four epicyclic trains of gear interconnected, so that different ratios and a reverse can be obtained.

The direct drive is achieved by engaging the clutch.

One train of epicyclic gearing is used for all the various ratios, its sun S1 being secured to a shaft D coupled permanently to the engine and its arm R1 to the shaft E which is coupled permanently to the driving road wheels and the various ratios are obtained by driving the annulus A1 at different speeds in relation to the engine speed.
FIRST GEAR

• First gear is obtained by applying a brake to the first gear train annulus A1. So that it is held stationary.
• The engine will then, be turning the sun gear S1. So that the planet gears will be rolling round inside the annulus A1 carrying their arm R1 round with them.
• As this arm R1 fixed to the output shaft its motion I imported to it.
• If A1 – fixed , S1 – driving, R1 – driven Where S1= 25 teeth A1= 100 teeth

First Gear ratio:

• Engine speed = 1000 rpm = sun S1 speed
• Arm R1 speed = wheel speed  = 1000 x S1/ (A1 +S1)
  = 1000 x 25 / (100 + 25) = 1000 x 1/5
  = 200
• Gear ratio: Driving/ Driven =1000: 200 = 5: 1
SECOND GEAR

• Second gear is obtained by holding the second gear train annulus A2 stationary by its brake.
• The main sun gear S2 still turned by the engine cause the planet gear to revolve and their arm R2.
• But this arm R2 is connected to the first gear train annulus A1 which therefore turns, speeding up the rotation of the planet gear and arm R1 and it turning the output shaft faster than was the case in first gear, i.e. less reduction.
• Second Gear ratio:
  • Engine speed = 1000 rpm = sun gear S1
  • Annulus speed = 100 rpm
  • Arm R1 speed = wheel speed = 1000 x 1/5 + (100 – (100 x 1/5) = 280 rpm
  • Gear ratio: Driving/Driven = 1000: 280 = 3.57: 1
Third gear
THIRD GEAR

• Third gear is obtained by holding the third gear sun wheel S3 by brake drum holding. Which is interconnected further the annulus A3 is an integral part of the second gear planet arm R2 which is in turn connected to the first gear annulus A1.

• The third gear arm R3 is connected to the second gear annulus A2 so driving it in same direction as the engine. i.e. increasing its speed so the drive is taken back through the second gear planets and arm R2 and the first gear train annulus A1 both of which are speeded up.

• The result is to speed up the first gear train arm R1 which are connected to output shaft.

• In other words by interconnecting the second and third arms, an increase of speed is obtained at the first gear train annulus, which increases the speed of the arm R1.
Third Gear ratio

- Engine speed  = 1000 rpm = sun gear S1
- Annulus speed  = 200 rpm
- Arm R1 speed = wheel speed = \( 1000 \times \frac{1}{5} + (200 - (200 \times \frac{1}{5})) \)  
  \[ = 360 \text{ rpm} \]
- Gear ratio: Driving/ Driven =\( 1000: 360 = 2.78: 1 \)

Reversed Gear ratio

- Engine speed  = 1000 rpm = sun gear S1
- Annulus speed  = −400 rpm
- Arm R1 speed = wheel speed  = \( 1000 \times \frac{1}{5} + (−400 - (−400 \times \frac{1}{5})) \)  
  \[ = −120 \text{ rpm} \]
REVERSE GEAR:
Cotal Electro Magnetically operated planetary gear box
Explanation

• The transmission employs four magnetic clutches.
• Clutch 1 being secured to driving pinion A1 & clutch 4 to driven shaft B.
• 2 & 3 are secured to transmission housing.
• Between 1 & 2 there is an armature C. It has ring gear R2 with a dual planet pinions.
• 1 is energized then R2 is rotated by A1.
• Energizing clutch 2 the ring gear is held from rotation.
• Since sun gear is rigidly secured to driving pinion A1, when clutch 1 is energized the planetary train is locked & power is transmitted through it directly.
• When 2 is energized then power is transmitted from A1 to planet carrier A2 at reduced speed.
• Carrier A2 is secured to carrier A3.
• Sun S3 of this second train is secured to armature H.
Contd…

- H can be held by clutch 3 (or) rotated by clutch 4.
- When held stationary, planetary train is active, and gives increased speed since planet carrier is driver & ring gear is driven.
- When it is locked, motion is transmitted directly.
- Thus two trains – each with 2 ratios – each ratio can combine with either ratio – total of 4 ratios.
- 1\textsuperscript{st} speed clutches 2 & 4 energized. Reduction ratio 2.17 in first train & direct drive in rear train.
- 2\textsuperscript{nd} speed clutches 2 & 3. Step down of 2.17 from first and step up of 0.72 from second.
- Over all ratio is $2.17 \times 0.72 = 1.56$.
- Direct drive – clutches 1 & 4 energized – both trains locked.
- When 1 & 3 energized, forward train is locked and rear function – over drive of $0.72 : 1$.
- Reverse gear is at the forward end of gear box.
Hydraulic control system for automatic transmission
Explanation

• The hydraulic control system of the automatic transmission is shown in figure. Which is a simplified diagram illustrating the basic principles.
• Hydraulic fluid is drawn from input and ensures that pressure is available as soon as the engine starts.
• The rear pump is driven from the output shaft so that pressure is generated in this pump as soon as the vehicle moves, and this feature provides a means of preventing the reverse and park mechanisms being engaged whilst the vehicle is in motion.
• Non-return valves ensure that hydraulic pressure can be available from either pump and the joint delivery is regulated to a suitable pressure by a pressure relief valve.
• The fluid at regulated pressure is fed to the converter which is kept full of fluid and a small flow from the converter is used for lubrication of the gearbox.
The main fluid supply is fed to the manual selector valve which is controlled by a steering-column selector lever, and this may be moved to any of five positions.

This valve may direct fluid under pressure to the reverse brake when a reverse ratio is obtained. In the low selection, fluid is applied to both the forward and low brakes and maintains the transmission in low gear.

Neutral selection is obtained by removal of pressure from all friction elements, and the park position engages a mechanical lock preventing rotation of the output shaft.

When the Drive selection is made the manual selector applies fluid under pressure to the Forward and Low brakes and also to the governor valve.

The governor valve is moved by the combination of an accelerator pedal movement together with the position of a centrifugal governor.
• At low road speeds the governor valve is blocked and the transmission is retained in low gear.
• At a higher road speed the governor valve moves to apply fluid at pressure to the multi-plate clutch so as to engage Intermediate gear.
• As the multi-plate clutch begins to take up the drive the pressure in the clutch rises and becomes sufficient to operate the relay valve and cut off the fluid supply to the low friction brake band.
• This relay valve carries out the transition from Low to Intermediate clutch.
• This relay valve corresponds to the more usual shift although in this case the valve is moved by spring force in opposition to hydraulic pressure.
The change into direct drive is effected by the application of fluid pressure to the single-plate clutch by the governor valve.

The other friction elements remain in the same condition as for the Intermediate gear so that no transition from one element to another is needed.

No smoothing device is incorporated for the take-up of this clutch, which relies on the capacity of the clutch piston to give a steady build-up of pressure.

Gear changes to lower ratios operate in the reverse sequence.
FORD T-MODEL
An example of the “all-spur” type of planetary transmission is the ford model T, with which millions of cars have been equipped.

A sectional view of this transmission is shown in figure.

Here, instead of power being applied through one of the sun pinions, it is applied to the planet carrier.

The flywheel rim A serves as planet carrier and driving member, having lateral studs secured into it which carry triple planetary pinions.

Gear B is the driven member, being keyed to the hub of clutch drum C, which in turn is secured to driven shaft D.

By applying a brake band to drum E, gear F is held stationary, pinion G rolls on it, and the smaller pinion H causes gear B to turn slowly in the same direction as pinion carrier A.
• By applying a brake band to drum I, gear J is held stationary; pinion H turns gear B slowly in the reverse direction.
• For the high gear or direct drive, the friction clutch locks clutch drum C to the engine crankshaft, and the gear rotates as a unit.
• The three pedals control the transmission and brakes. When the left pedal is push down all the way, the car is low gear.
• To remain in low gear, you must continue pushing on the left pedal. (It’s been said that you push a Model T up a hill in low gear with your left foot!).
• If the left pedal is pushed to the halfway position, the car is in neutral.
• When the left pedal is completely released (not depressed at all), the car is in high gear.
If the car is in neutral (either by depressing the left pedal halfway or by moving the lever to the left of the pedals to an upright position) the middle pedal can be pushed to engage reverse gear.

The right pedal is a brake that acts on the transmission when pushed. Operating the brake and transmission sounds more difficult.

After some practice, most drivers don’t give it a second thought.

Interestingly, the Model T has a planetary transmission that’s the forerunner of the transmission. It’s very similar to an automatic transmission except you use foot pedal pressure to operate the bands rather than hydraulic pressure and it doesn’t have a torque converter.
• The lever at the right and under the steering wheel is the hand throttle. It controls the speed, much like the control found on the tractor or riding mover.

• Model T’s were made from 1908 until 1927. Over 15 million Model T’s were produced.

• Far more were produced than any other car until the Volkswagen Beetle overtook its production in the 1970’s, at a time when two-car families become the norm.

• The impact of the Model T’s in its day is hard far us to imagine, but in the early 1920s, half of all cars on the road worldwide were Model T’s.

• A Model T in good mechanical condition will cruise all day at 30 to 35 mph. Most can go 45 to 50 mph but the engine is working pretty hard at these speeds, so most drivers go this fast only briefly.