and the turbine wheel **44**, is supported rotatably on a turbine hub **52**, which is connected driveably to input shaft **12**. A hydraulically operated bypass clutch **54** alternately mechanically connects engine shaft **40** to input shaft **12** when clutch **54** is engaged, and allows shaft **40** to drive the impeller hydraulically when clutch **54** is disengaged. The torque converter produces torque amplification and speed reduction until it reaches coupling speed.

Input shaft **12** is connected, preferably through torque converter **46**, to a source of power, such as an internal combustion engine or electric motor. Rear output shaft **14** is driveably connected to the drive wheels of a motor vehicle, preferably to the rear wheels. Front output shaft **15** is driveably connected to the drive wheels of a motor vehicle, preferably to the front wheels. Alternatively, output shaft **14** can be connected to the front axles, and output shaft **15** can be connected to the rear axles.

Variable ratio drive mechanism **16** includes a first sheave assembly, which includes pulleys **54, 56** supported rotatably on input shaft **12**, and a second sheave assembly, which includes pulleys **58, 60** supported rotatably on intermediate shaft **26**. The axial position of one of the first pair of pulleys **54, 56** is fixed on the input shaft, the other pulley of the pair is moveable axially along the shaft, preferably in response the hydraulic pressure applied to an actuating device, so that the radial position of the drive belt **62** moves in accordance with the axial position of the axially displaceable pulley due to the inclined surfaces of the pulley faces that engage driveably the lateral surfaces of the drive belt **62**. Similarly, one of the pulleys **58, 60** on shaft **26** is fixed in its axial position, and the other pulley is axially displaceable so that the inclined inner faces of the pulleys are continually engaged at a variable radial position with lateral surfaces of drive pulley **62**. Movement of the displaceable pulleys is mutually coordinated so that they maintain driving contact with the belt. In this way the speed ratio produced by mechanism **16** is continuously variable.

The layshaft gearset **20** includes a pinion **63** coaxial with input shaft **12**; and a gear **64**, supported by a overrunning clutch **66** on shaft **14**. Overrunning clutch **66** provides a one-way drive connection between gear **64** and shaft **14**. Alternatively gear **64** may be rotatably fixed to shaft **14** without use of clutch **66**.

The planetary gearing **22** includes a sun gear **70** driveably fixed to input shaft **12**, ring gear **72** coaxial with the sun gear, a first set of planet pinions **74** meshing with the ring gear and rotatably supported on a carrier **76**, a second set of planet pinions **78** meshing with the sun gear and planet pinions **74** and rotatably supported on carrier **76**, which is driveably connected to pinion **63**.

The elements of the transmission according to this invention are controlled operatively by various clutches and brakes, preferably hydraulically actuated friction devices, including low brake **98**, first and second reverse clutches **100, 101**, transfer clutch TRF **102**, and torque on demand (TOD) clutch **104**, or a reverse dog clutch **106**, an alternative to reverse clutch **101**. These friction elements may be hydraulically, mechanically or electrically operated. Low brake **98** alternately driveably holds against rotation and releases ring gear **72** to rotate; first reverse clutch **100** alternately mutually driveably connects and releases shaft **12**, pinion **63** and carrier **76**; transfer clutch TRF **102** alternately driveably connects and releases pulleys **54, 56** and shaft **12**; second reverse clutch **101** alternately driveably connects and releases gear **64** and shaft **14**; and torque on demand (TOD) clutch **104** alternately driveably connects and releases shafts **26** and **15**. An alternative to the hydraulically actuated reverse clutch **101**, shown in FIG. **3**, is the dog clutch **106** of FIG. **1** having a coupler **108** displaceable along the axis of shaft **14** and carrying radial dog teeth **110** adapted to driveably engage axially directed recesses **112** extending radially from the inner surface of member **114**, which is fixed to gear **64**.

First gear is produced by engaging low brake **98** and releasing all the other friction elements, except that clutch **104** is activated when drive to both front and rear axles is desired, as discussed below. This action causes OWC **66** to driveably connect shaft **14** and gear **64**, and grounds ring gear **72**. Sun gear **70** is driven by the engine; therefore carrier **76** revolves about the sun gear **70** slower than, and in the opposite direction from the speed and direction of the engine. The layshaft gearing **20** multiplies torque to shaft **14** and reverses its direction of rotation back to the direction of the engine and shaft **12**. Therefore, the rear wheels are driven by shaft **14** at a reduced speed in relation to that of shaft **12** through operation of pinion **63** and gear **64**, and in the same direction as that of shaft **12**. Gear **64** is connected to sprocket **24** through OWC **66** and shaft **14**. If the front axle is to be driven also, intermediate shaft **26** is driven through fixed ratio mechanism **18** in the same direction as that of the engine. TOD clutch **104** is engaged to directly connect front output shaft **15** to the power source, or that clutch is modulated to control the magnitude of torque transmitted to shaft **15**.

An upshift to the low speed end of the continuously variable range is accomplished by engaging transfer clutch **102**, and disengaging the other friction elements. These actions cause one-way clutch **50** to overrun. After the upshift is completed, low brake **98** can be disengaged to prevent clutch **100** from counter-rotating.

In the CVT mode, TRF clutch **102** connects input shaft **12** to a first sheave, whose pulleys **54, 56** drive the pulleys **58, 60** of a second sheave through belt **62** at a variable speed ratio that depends on the radial positions at which belt **62** engages the sheaves. Shaft **26** drives sprocket **28,** which drives the rear output shaft **14** and the rear wheels due to engagement of chain **30** with sprockets **28, 24**. The TOD clutch **104** can be used to driveably connect the pulleys **58,60** of the second sheave to the front output shaft **15**.

Preferably the speed ratio produced in first or low gear through operation of gear unit **22** is spaced slightly from the speed ratio at the lowest end of the continually variable range produced through operation of the variable ratio drive **16**. In this way the transition from first gear to the lowest variable gear ratio is an upshift.

Preferably the gear ratio produced in low gear is 3.061; the gear ratio at the low speed end of the continually variable range is 2.018; the gear ratio at the mid-range of the CV range, where the speed of the two sheave assemblies is substantially equal is 1.0; the gear ratio at the high speed end of the CV range is 0.525; and the gear ratio in reverse drive is −2.778. Pinion **63** has 27 teeth; gear **64** has 75 teeth; sprocket **24** has 114 teeth; and sprocket **28** has 131 teeth. Sun gear has 49 teeth, ring gear **72** has 103 teeth, and pinions **74, 78** each have 27 teeth.

Reverse drive is produced by engaging reverse clutch **100**, disengaging reverse clutch **101** or dog clutch **106**, and disengaging the other friction elements, except that TOD clutch **104** may be engaged to drive the front wheels when desired, as explained below. Clutch **100** couples shaft **12** and pinion **63**. The layshaft gearing **20** drives shaft **14** in the opposite direction from that of the engine and multiplies