DEVELOPMENT OF TRANSMISSION

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DEVELOPMENT OF TRANSMISSION

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THESIS

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ABSTRACT

An internal combustion engine does not develop its full power at low speeds; therefore, an automobile cannot pull much of a load at low speed, and gears must be interposed between the engine and driving wheels. This permits the crankshaft to turn at a speed necessary to produce the desired power while the wheels turn at a speed required by road conditions or grades. To secure flexibility of operation 3 and sometimes 4, speed ratios are provided. To back the car, a set of gears are arranged in the transmission. The gears, shafts, and other parts necessary for varying the forward speed and obtaining a reverse are all contained in a housing or gear box, and the assembly is called a Transmission or a Torque Converter.

The transmission may be located:

(a) as part of a unit with the engine and clutch

(b) as a separate unit between the clutch and rear axle

The main purpose of a transmission, therefore, is to provide suitable gear ratios between the engine and rear wheels for all driving conditions and to give a greater output torque than the engine torque. The torque ratios can be secured in several ways.

Types of transmission:

1. Sliding gear transmission
2. Hydraulic torque converter
3. Hydraulic drive

Old style progressive type. This type was discarded because it was necessary to pass one gear through another, which made a clashing noise and was difficult to operate at times.

Selective gear type transmission. This is so called because it is possible to engage any set of gears desired in moving from the neutral position without passing through any other gears. This type is preferable because of the absence of noise from the gears and the ease of operation. We have to remember that gears cannot be shifted until the lever is brought to neutral position.

Some modern transmissions now use either hydramatic drive or dyna flow. The combination of a fluid coupling and a fully automatictransmission is an ideal unit for transmitting power from the engine to the wheels. This drive takes the place of two conventional units, the clutch and the selective sliding gear transmission.

TRANSMISSION

Internal gears run more silently than spur gears: -

American motorists want their cars to have exceptional performance. They want them to be capable of great acceleration without the inconvenience of frequent gear shifting. To meet their demands, manufacturers have increased their engine speeds and at the same time increased the rear axle ratios. In this way, they found it possible to increase both the acceleration on high and the limiting grade which can be climbed on high gear, without increasing the engine weight.

Up to 35 mph. the engine power reserve is almost as large with the smaller as with the larger rear axle ratio. The main advantage gained by decreasing the rear axle ratio is that the average engine speed is much lower, in consequence of which the operation is much smoother and the wear and tear of the engine is reduced.

Recourse was, therefore, had to the internal gear which is both more efficient and more quiet than the spur wheels. There is no power loss when one perfectly elastic solid rolls over another, and hardened steel has a high degree of elasticity.

This transmission uses internal gears instead of dogs. The gear has internal teeth which mesh with a smaller gear on the inside of gear. The gear shift lever is usually of the ball and socket type. The movement of lever is in a ball and socket.

3 Speed and 4 Speed Transmissions

One of the most important of these relates to the number of changes of gears. This is a somewhat involved problem, as it affects the type and size of engine to be employed, the rear axle gear ratio, the design of other units such as the clutch, propeller shaft, universal joints, the weight of the car, and its stability.

Easier shifting and quicker operation in next-to-top speed appears to have been attained by the use of the 4 speed transmission. Quiet operation and easy shifting can be and are realized in some 3 gear sets also.

Advantages of 4 speed gear sets:

1. Fewer engine revolutions per mile with resulting decrease in engine wear and friction losses.

2. Lower engine speeds with consequent decrease in engine noise and vibration, and less fatigue in driving.

3. Lower propeller shaft speeds resulting in less whip and noise, or permitting the use of lighter and less expensive parts.

4. Improved fuel economy resulting from a better load factor, and lower oil consumption.

5. Ability to accelerate more rapidly without excessive gear noise in the next-to-top speed.

6. Shorter steps between gears, and a lower gear for emergency use.

7. General excellent performance in third speed in traffic.

Whatever the design may be, we have to retain the standard shift in any new gear set that may be adopted. If we are to have 4 speeds, the 3 top speeds should require the same shifting as the 3 speed type, the emergency low speed being latched out or otherwise arranged to prevent accidental engagement. Any other arrangement is likely to confuse operators in emergencies and lead to many accidents otherwise avoidable.

Internal Gears:

In a 4 speed transmission, changes from 3rd to 4th speed and vice versa will be more frequent than any changes of gears in a car with a 3 speed transmission, and so it is essential that the gear be so designed that this change can be made easily. It is necessary, therefore, that the moment of inertia of all the parts rotating with the clutch when the device affecting the change over from 3rd to 4th is in neutral, should be very small.

Changing into 1st and 2nd gear and reverse will be made somewhat more difficult, because the internal gears will rotate with the clutch.

The outstanding development from 1924 to 1928 has been the application of the internal gear to the automobile transmission. The general effect is to give a next-to-top speed that is almost as silent as the direct with a sure and easy shift between these two speeds.

The internal geared system has shown astonishing resistance to wear and breakage. The remarkable wear and strength factors of the internal gear make it ideal for this field, while the easy gear shift makes it particulary attractive to the driver.

ELIMINATION OF GEARS

Numerous attempts have been made to eliminate gears from the transmission and to use in their stead, electric, hydraulic, or friction units. In using an electric transmission, it is possible to dispense with the flywheel, clutch gears, the present starting motor and one set of brakes.

In the hydraulic system, a hydraulic motor, a pump, a control system and suitable piping are included. Gear shifting has been one of the great drawbacks of automobile operation since the days of the first sliding gear transmission.

A constant mesh transmission has some advantages:

1. Ease of gear shifting under any conditions
2. A high degree of quickness of operation
3. Flexibility with very little divergence from conventional designs

PRINCIPLES OF AUTOMATIC OPERATION

All the engines have the characteristic that as the torque load on them is increased, if no change is made in the control or adjustment of the engine, its speed will decrease; consequently it would be possible, by fitting the engine with a governor, to connect this governor up to shift the gears or to increase in some other way the transmission ratio or torque multiplying ratio when the engine speed decreases or vice versa. The car is fitted with a device that affects shifting of the gears automatically by a centrifugal governor.

When the car is at a stand still, the gear is in neutral, and if the driver wants to start the car he engages the 1st speed by hand. As soon as the engine reaches a predetermined speed on this gear, the governor shifts the car to second gear, and so on. If it is necessary to reduce speed on account of traffic or other conditions, the operator closes the throttle valve, thus reducing the engine speed, and the centrifugal device then shifts automatically to a lower gear. On the whole, it seems to be a simpler and better plan to use the torque reaction to produce a change in the transmission ratio when required.

The standard gear rear axle gear ratio varies from 3.7 to 5.1.

Transmission is replaced by hydraulic torque converter in Leyland commercial vehicles.

Probably the first hydraulic torque converter to be placed in production by an established firm was offered by Leyland Motors in 1934. In this mechanism all multiplication of engine torque for acceleration and hill climbing is effected hydraulically, so that a mechanical change gear is dispensed with entirely. Under ordinary conditions of operation the drive is direct, the hydraulic mechanism being disengaged. Changes in torque conversion ratio take place automatically, but the change from hydraulic drive to direct drive is made by hand. Reverse is obtained through a special reverse gear which is combined with the double friction clutch and the hydraulic mechanism in a unit corresponding in form and size to the flywheel housing and transmission unit of mechanically driven vehicles.

There are four control members:

1. The accelerator pedal
2. The brake pedal
3. The direct drive pick-up lever
4. The **reversing** lever

The latter normally remains in the position for forward drive and is operated only when it is necessary to back up. A double friction clutch is used.

With the clutch control mechanism in one position, the engine crankshaft is directly connected to the main drive shaft and the drive is therefore direct from crankshaft to propeller shaft.

In the opposite position of the clutch control mechanism, the engine crankshaft is connected to a hollow shaft which carries the impeller of the hydraulic unit. There are four essential elements in the bus type hydraulic torque converter.

1. A double friction clutch which permits the connecting of the engine either to the torque converter or directly to the propeller shaft as required.

2. The hydraulic system of the converter

3. The free wheeling unit to permit over-running of the converter

4. The reversing gear

1. The double clutch is operated by means of a lever in the driver's cab, through a toggle mechanism. The friction on clutches have very little work to do as the vehicle is not being accelerated from a standstill to maximum speed on a slipping clutch as with mechanical transmission. The engine can be idled with the clutch for the hydraulic drive engaged and the car is then started and accelerated by merely depressing the accelerator. Whatever slipping there is up to the maximum speed attained through the hydraulic drive takes place in the hydraulic unit. When the direct drive pickup lever is moved to the direct drive position, the

vehicle is already moving at very nearly the speed corresponding to direct drive for the given engine speed and there is, therefore, very little slippage at this clutch also.

As the change is made from hydraulic drive to direct drive there is no interruption in torque and no corresponding loss of speed. As regards efficiency, it is claimed that owing to the steady acceleration of a direct drive and the provision of a free wheeling unit, this torque converter compares favorably with mechanical transmission. The hydraulic unit protects the transmission members behind it against torsional vibration of the engine, and the engine cannot be raced in running down hill at high speed.

2. Torque converter consists essentially of the combination of a centrifugal pump with a three stage hydraulic turbine in the same housing. The pump impeller, which is coupled to the crankshaft by means of the friction clutch is similar in form to an impeller of the centrifugal pump of the water cooling system. The turbine, which is connected to the propeller shaft through the free-wheeling unit, consists of a bladed rotor on which three separate series of blades are fixed in such a way that they are separated by two series of stationary blades fixed to the casing.

The housing is completely filled with fluid so that when the engine power is being transmitted to the pump impeller, the fluid is driven from the pump to the first set of rotor blades, then through the stationary blades, where the direction of flow is changed so that the fluid impinges on the second set of rotating blades. Next the fluid passes through the second set of stationary blades where it is again redirected to impinge on the 3rd set of moving blades after which it returns to the pump. Owing to the shape of the blades and the fact that there are three sets of turbine blades in series, the engine torque can be multiplied in ratios up to 4.8 to 1. New fluid under certain conditions is likely to gasify slightly and, to insure the removal of the gas and the replacement of the gasified fluid, a permanent leak to the reserve tank is provided through a control value and fluid is drawn from this tank and added to the supply in the housing, as required, by an injector. To prevent the fluid from reaching excessive temperature under conditions of prolonged use of the hydraulic drive, a smaller cooler is incorporated in the fluid circuit and located outside the chassis frame. The fluid used in the converter consists of a mixture of lubricating oil and kerosene, or of diesel engine fuel.

3. Free wheeling unit. - The free wheeling unit is mounted on the shaft driven by the turbine rotor and so is effective only when the drive is through the hydraulic unit. It has the effect of completely isolating the converter, which later comes to rest immediately after its friction clutch is disengaged,so that there is no hydraulic loss when the drive is direct. The object of the free-wheeling is to make coasting safe while the converter is engaged by its friction clutch.

4. The reversing gear is of the spur gear type and is provided with a synchronizing device which facilitates engagement.

The Operation. - The engine is started up with the operating (reversing) lever in the neutral position. To start the vehicle this lever is pushed into the position for forward motion, and then the engine is speeded up by depressing the accelerator. The car gains speed and when it has attained the usual top gear speed, the accelerator pedal is slightly released and the control lever is pulled back into the direct drive position. Thereafter, the road speed is controlled by the accelerator in the usual way.

When desiring to stop the operator pushes the control lever forward and then stops the vehicle by means of brakes. To restart, he releases the hand brake, presses the accelerator pedal until top gear speed is reached and then again pulls the control lever back.

THE DEVELOPMENT OF AUTOMATIC TRANSMISSIONS

Several different types of transmission were used on the early gasoline cars, including the individual clutch type, the planetary type transmission, the sliding gear transmission and the friction drive.

Aside from their lack of sufficient flexibility, the chief objection to the early transmission was that they were difficult to handle. It was believed that this difficulty could be overcome by making the gear change or shift automatic, and it is a noteworthy fact that the first car with an automatic transmission was placed on the market as far back as 1904.

By 1910, the sliding gear transmission had come into use on nearly all stock cars, the one important exception being the Ford Model T, which retained the planetary gear until 1928. There was no basic change in transmissions during the second and third decades of the present century, although a number of cars were equipped with so-called preselective transmissions. This operated by means of a small lever carried on the steering post. The driver could at any time set the mechanism for the change he expected to become necessary next, and then when the time for the change arrived, he would press down on the clutch pedal (or let up on the accelerator pedal) and the gear would be changed in accordance with the setting of the pre-selector lever, either by physical force exerted on the clutch pedal, by a solenoid, or by a vacuum cylinder.

Towards the end of the twenties the Warner Gear Co. brought out its Hi-Flex Transmission, a four speed design incorporating Internal Gears, and although this did not prove a permanent success, it caused such a stir in transmission circles that it must be considered as having definitely reopened transmission problems. Since that time, transmission gears have been made silent and the gear synchronizing device was introduced, which practically eliminated clashing and made shifting possible under all conditions, with the result that the conventional sliding or shifting transmission has become a rather satisfactory device: light and compact, highly efficient, easy to operate, silent in operation, and inexpensive to manufacture. A continuously variable type, of course, would be preferable.

There seems to be only one really serious objection to the present type of conventional transmission, and that is that it calls for the use of three pedals for the control of the car. Two of these pedals, the accelerator and the brake, must be operated by the same foot and the necessary shifting of the foot from the accelerator to the brake pedal adds to the time lag in bringing the car to a stop in an emergency. Besides it is inconvenient, and in addition there is the possibility of the foot slipping from the brake onto the accelerator pedal or of the accelerator being depressed instead of the brake pedal by mistake. It would therefore seem that a transmission which reduces the number of pedals to two would be a real improvement.

As we have suggested in the foregoing section, transmissions may be divided into: (1) stepped, (2) continuously variable types.

Either of these may be controllable or automatic. The driver in every case has control over the speed of the car by means of the accelerator.

Infinitely Variable Transmissions:

The first type of automobile transmission which made it possible to have an infinite number of graduations in the transmission ratio was a friction disc drive. This was regular equipment on four or five early cars, but it was only moderately successful with the low engine powers of that period, and it would be entirely impractical with our modern passenger car engines of around one-hundred HP.

HYDRAULIC TRANSMISSIONS

Another type of infinitely variable transmissions on which a great deal of work has been done with a view to adapting it to automotive uses is the hydraulic. Hydraulic transmissions naturally divide into two classes, hydrostatic and hydrokinetic. In the former the working fluid is placed under pressure and set in motion by a pump, usually of the multi-cylinder plunger type, and the fluid moved by this pump acts on the pistons of a hydraulic motor. The rate at which power is being transmitted by such a device is measured by the product of the fluid pressure, and by the volume displaced by the plungers of the pump in unit time. In order to change the transmission ratio, the stroke of one of the two elements is varied, usually that of the pump.

For instance, if the pump stroke is halved while the speed of rotation of the pump, and the HP input remain the same, then the pressure to which the fluid is subjected will be doubled, and with twice the fluid pressure the torque on the shaft of the hydraulic motor will be doubled while its speed will be halved because of the lower rate of delivery by the pump.

It seems that with the great increase in the power of passenger car engines, such hydrostatic transmissions have become entirely unsuitable for passenger car use. All of the power transmitted is at all times converted first into hydraulic power, and then converted back into mechanical power, and the double conversion involves considerable losses. It is rather doubtful whether such a transmission in automobile use under normal conditions would show more than 75% efficiency, and a loss of 25% of the power in the transmission would be highly objectionable.

In hydrokinetic transmissions, a fluid is set in motion by a propeller provided with blades. In this case, power is being transmitted by setting the fluid in motion by the driving member, and then letting it spend its kinetic energy on the blades of the driven member.

If both driving and driven members are enclosed in the same housing and the fluid passes directly from the blades of the driving to those of the driven member, the torque on the driven member will be not greater than that on the driving member, and as the speed of the driven member can never quite equal that of the driving member, we have a device akin to the slipping clutch. In more correct technical terminology it is known as a hydraulic coupling. There is no slipping of gears or of dog clutches engaging gears, and the fluid fly-wheel introduces a certain flexibility which prevents shocks. Although there is a slight loss in the "flywheel" under normal driving conditions, it amounts to only a few percent and it is therefore much more efficient than the hydrostatic type of transmission.

The reason the fluid flywheel cannot increase the engine torque is that it has no member on which any additional torque could react. To obtain an increase in torque a third set of blades must be provided carried on a member that is mounted rigidly on the engine or on the chassis frame.

Hydraulic couplings and hydraulic torque converters can be combined with mechanical units in various ways to secure automatic changes of gear ratio together with high efficiency of operation under most driving conditions. All multiplication of engine torque for acceleration and hill climbing is effected hydraulically, and changes in "gear ratio" take place automatically.

When the vehicle approaches the normal driving speed, the driver sets the direct drive pick-up lever by hand and therefore the drive is direct. Reverse is obtained by means of a special reversing gear which is combined with a

double friction clutch and a hydraulic mechanism. There are four control members as follows:

1. the accelerator pedal
2. the brake pedal
3. the direct drive pick-up lever
4. the reversing lever

The latter is normally in the position for forward drive and needs to be moved only when it is desired to back up. The direct drive position in the crankshaft is coupled directly to the propeller shaft with the clutch control lever in the opposite position. The crankshaft is connected to the tubular shaft, which carries the propeller of the hydraulic torque converter. It is not necessary to accelerate the vehicle with the friction clutch. The latter can be fully engaged before the vehicle starts, and acceleration is accomplished by means of the hydraulic unit by opening the throttle and speeding up the engine. When the direct drive pick-up lever is engaged the vehicle is already traveling at a speed close to normal, and there is therefore a minimum slippage and a minimum of wear and tear on the clutch lining. This change is made without interruption in the torque.

The hydraulic torque converter comprises a centrifugal pump and a three horsepower hydraulic turbine in the same housing. The turbine wheel is connected to the propeller shaft through a free-wheeling unit whose object is to disconnect the hydraulic unit from the drive mechanism when the direct drive is used so that the propeller and turbine wheel will not rotate and will not cause any hydraulic losses. When the change to direct drive is made, the operator lets up on the accelerator pedal slightly.

The following points in connection with the design of hydraulic transmissions are the results of experience.

1. Idle fluid must be reduced to a minimum. Fluid circulation must be as natural, easy, and short as possible. The flow must be full, continuous, and free from obstructions and undue changes throughout the whole circuit.

2. Action and reaction must be in close proximity consistent with working clearances. Parts moving relative to each other should be separated by an oil film of up to .085 inch depending on location. Neglect of this may lead to serious frictional loss.

3. Good lubricating quality, lasting body freedom from acid and air are important.

4. The freezing point and the coefficient of friction must be low, while the boiling point, flash point and specific heat must be high.

Sperm oil, winter grade, has proved the most satisfactory working fluid under prolonged and exacting road tests.

OPERATION OF FLUID FLYWHEELS

Now that hydraulic couplings (fluid flywheels) and transmissions are coming into use, an elementary exposition of their operating principles is necessary. The fluid flywheel or hydraulic coupling is a device in which there is a liquid flow whenever at least one of its members is rotating.

The device consists of two rotors, one connected to the driving shaft, and the other to the driven shaft. Both rotors are provided with vanes which form between them cells or passages through which the working fluid may circulate. The disc or rotor **A** connected to the driving shaft is called the Impeller, and the rotor B connected to the driven shaft, the runner. The impeller forms a housing of annular shape which is completely filled with a liquid. The driven shaft has a bearing in the impeller housing and a suitable seal is provided to prevent escape of liquid through this bearing.

Now let us assume that the impeller **A** is being rotated by the engine and that runner B is being held from rotation in **some way**, by engaging the brakes of the car. The liquid in the cells between the vanes of the impeller will participate in the rotary motion of the impeller and will be subjected to centrifugal force. Since runner B is being held, the liquid in its cells is not subject to centrifugal force; hence the liquid in the impeller under the influence of the centrifugal force upon it, will leave the cells of the impeller near the outer circumference and enter the cells of the runner, and the liquid thus displaced from runner will enter the impeller near the inner circumference.

The liquid leaving the cells of the impeller, owing to its rotary motion, impinges against the vanes of the runner, thereby producing a driving force on these vanes. A driving force on the vanes of the runner is equivalent to a torque on the shaft on which the runner is mounted, that is, the driven shaft.

If the brake is now released, the low gear in the transmission engaged, and the friction clutch let in again, the torque on the driven shaft is less than the torque which the engine is capable of developing, and the runner will be set in motion. Between the cells of the impeller and those of the runner there is a certain free space and this space is filled with liquid having a dual motion, an angular motion around the common axis of the two rotors, and superimposed upon this, a motion in the direction parallel to the axis of the rotors.

When the driven shaft with its runner is rotating in the same direction on the driving shaft with its impeller, the liquid in the cells of the runner also rotates and therefore is subject to centrifugal force, the same as the liquid in the cells of the impeller. The direction of the centrifugal force in each case is radially outward (drawing) and the two forces therefore are in opposition to each other in the fluid circuit, tending to cause the liquid to flow in opposite directions.

However, as long as power is being transmitted from the driving to the driven shaft, this runner rotates slower; consequently the centrifugal force on the liquid in the cells of the runner is less than the centrifugal force on the liquid in the cells of the impeller and the difference between these two forces causes the liquid to flow through the circuit. Power is being transmitted from the driving to the driven shaft.

The question now arises as to the relation between the torque on the driving and driven shafts, and between the angular speeds of these shafts. Under steady driving conditions at least, the torque on the driven shaft will always be the same as the torque on the driving shaft in accordance with the principle that to every action there is an equal and opposite reaction.

The torque which is transmitted from the impeller to the runner is equal to the change of momentum of the liquid in the impeller (or in the runner). At the outlet from the impeller, the momentum of the fluid is equal to the radius of the outlet in ft., by the tangential velocity of the liquid at the outlet in ft. per second. Similarly, the moment of the liquid at the inlet to the impeller is equal to $\frac{w}{g}$ x radius of impeller inlet x tangential velocity of the liquid at the inlet in feet per second. The difference between these two products is the change in momentum of the liquid and therefore the torque transmitted in feet.

There is, of course, a certain amount of loss in the coupling due to internal friction of viscous liquid and skin friction between the liquid and metal surfaces. Consequently, less power is received by the runner than is conveyed from the engine to the impeller.

The difference between the speeds of rotation of the impeller and runner is referred to as the SLIP and is a measure of the power loss in the coupling.

During periods of acceleration there is a great deal of slip and consequently considerable loss. When the car is at a standstill there is a 100 percent slip, and the efficiency of the coupling therefore starts from zero. At constant speeds the slip is about 2%.

The hydraulic coupling takes the place of the engine flywheel and forms a flexible link in the transmission. It cannot replace the friction clutch in conjunction with a transmission in which the deficient speeds are engated by sliding gears into mesh.

While a hydraulic coupling will not multiply the engine torque for acceleration and hill climbing, a very similar device called hydrokinetic torque converter is capable of doing this. To multiply the torque, it is necessary to provide a third member called a Reaction Member.

A is the impeller, B is the runner, C is the reaction member. This device obeys two fundamental laws:

(1) when running at constant speed, the active torque and torque reaction must be equal and opposite.

(2) The energy imported to a given mass of the liquid by the impeller minus the internal loss attributable to that mass, must be subtracted from it by the runner. No energy is absorbed by the reaction member as that member has no motion.

The liquid in the cells of the impeller and runner has a dual motion. It flows through the circuits in planes passing through the axis of the converter and it rotates about this same axis with the impeller and runner.

The liquid enters the cells of the impeller near the axis of rotation and as it passes to the outlet from these cells, which is further from the axis of rotation, its velocity and its k. energy increases. The liquid retains all of this k. energy as it enters the cells of the runner. But in the cells of the runner the liquid flows toward the axis of rotation and hence its kinetic energy is decreased. The energy lost by the liquid in passing through the runner is conveyed to the latter and by it to the driven shaft. If the runner runs one-half as fast as the impeller, the torque on it will be nearly twice the impeller torque. The difference between these two torques will react on the reaction member. The liquid presses against the vanes of the reaction member in the same angular direction as it presses against the vanes of the impeller.

HYDRAMATIC TRANSMISSION

With the adoption of hydramatic transmission, Oldsmobile has done away with the conventional friction clutch and clutch pedal. Still, the operator has complete control by means of the shift lever and the accelerator pedal. The shift lever has four distinct positions: neutral, high, low, and reverse, which are reached in the order named by a continuous motion.

When the engine is being started, the shift lever is in neutral. Finger tip shift direct from neutral to hi is all the shifting required under normal conditions, since the transmissions will shift automatically from 1st to 4th through the intermediate gears at predetermined road speeds varying with the throttle position, and with the engine idling, the car will not move when in the driving positions.

When the shift lever is shifted manually into low, the transmission can operate in 1st and 2nd gears only. It will shift automatically from 1st to 2nd at a road speed which varies with the throttle position. The low position of the shift lever is to be used only in emergencies on extremely steep grades and when it is desired to use the engine as a brake. It is never used in normal operation.

A valuable feature of this transmission is that the car can be locked positively on a grade when the engine is dead by placing the shift lever in reverse. This is effected by means of a spring loaded band on the rear unit which locks the reverse unit.

The entire transmission is filled with a fluid lubricant covered by precise specifications. The fluid specified has been found satisfactory at a temperature of 115°F. down to -15°F.

An important feature of the mechanism is the influence of the throttle (or accelerator pedal) position on the road speeds at which gear changes take place. At part throttle, any particular shift takes place at a lower car speed than at full throttle. This, of course, is highly desirable, for when one wants to accelerate rapidly, the accelerator is pushed far down, and the transmission then remains in a given gear up to a higher road speed than it otherwise would, which results in a higher rate of acceleration.

With the throttle fully open the shift from:
1st to 2nd occurs at round 15 m.p.h.
2nd to 3rd occurs at round 30 m.p.h.
3rd to direct drive occurs
at round 60 m.p.h.

The housing of the fluid coupling, which is sealed, receives its actuating fluid directly from the transmission housing, to which the fluid returns through a pop-off valve and a separate return line. This constant circulation of the fluid prevents localization of temperature effects and keeps down peak temperature.

The transmission consists essentially of four units:

1. Within the engine flywheel, there is a fluid coupling.

2. Then comes one behind the other -- 2 planetary gear sets of the type comprising an internal ring gear.

3. Planetary pinions in mesh with both the sun gear and the internal gear.

4. And finally in the rear part of the transmission housing there is a reversing gear also of the planetary type.

Each of the planetary units employed in forward drive is provided with a brake band by means of which one of its members can be held from rotation, and with a clutch by which the whole unit can be locked together to transmit the power directly. The two units are referred to as the front unit and the rear unit respectively.

The flywheel is bolted to the crankshaft while the fluid coupling covering is bolted to the flywheel. For 1st speed, the sun gear of the front unit is held from rotation by a brake band.

Bands . . . . both applied

Clutches . . . . . both released.

When the manual valve is moved to the "drive range" position, it cuts off the oil that releases the rear servo, allowing the spring to apply the band, and it directs oil to the apply side of the front servo. With both front and rear bands applied, the transmission is in 1st speed.

The brake band of the front unit is applied by oil pressure. While the brake band of the rear unit is applied by both spring and hydraulic pressure, the fluid coupling is kept filled under pressure by an oil pump.

For 2nd gear:

Bands . . . . Front released and rear applied.

Governor pressure increases with vehicle speed to a point where it will overcome the shifter valve spring and automatically open the valve.

3rd speed:

Bands: -- Front applied. Rear released.

The 2 to 3 shifter valve opens at a higher vehicle speed than the 1 to 2 valve because of greater spring tension. The front servo apply pressure, then applies the front unit band, causing this unit to go into reduction. With the front unit in reduction and the rear unit in direct drive, the transmission is in 3rd speed.

Bands: --- Both released.

In 4th gear both planetary units are locked and the drive is direct, except for the slippage in the fluid coupling.

Reverse:

Reverse anchor ------ locking reverse internal gear

Manual lever ------ reverse position.

Bands ---- Front applied. Rear released.

To obtain reverse, the manual valve is moved into the reverse position with the following results:

a. It directs it to the front servo to apply the Band.

b. It directs oil to the rear servo to release the Band.

c. It cuts off the oil to the govenor so there can be no upshift in reverse.

Operation of the automatic feature depends upon the oil pumps which build up a pressure of 80 p.s.i. There is a large pump at the front end, operated at engine speed, whose function is to produce pressure at starting so as to establish actual running conditions. It will deliver 80 lbs. pressure immediately. The second pump, a smaller unit, is mounted at the rear and is driven by the output shaft, as is the govenor. The rear pump picks up the pressure as soon as the car moves, permitting the front pump pressure to drop to around 20 p.s.i.

The hydraulic control system:

This system supplies the oil pressure necessary to actuate the clutch pistons and brake bands of the planetary units. Oil is admitted to the various cylinders at the proper time by a system of balanced valves. Its pressure balances some variable force. In the case of the throttle valve, a spring pressure is balanced, while in that of the govenor valve the forced balanced is centrifugal.

Oil is admitted to the body of the govenor valve through the 80 lb. line from the pump. The govenor is driven from the transmission output shaft and, as it spins, the centrifugal force so positions the valve, that a port is opened and some of the oil is admitted to the valve, with the result that a pressure is built up which opposes the centrifugal force acting on the valve. This results in a govenor pressure which increases with car speed. This govenor pressure is applied to one end of a shifting valve, as for instance the valve which makes the shift from 3rd to 4th gear. To the opposite end of this valve is applied a fixed spring pressure and another variable hydraulic pressure, known as the throttle valve pressure. This latter pressure is determined by the position of the throttle and is regulated by another balanced valve.

When the force exerted on the 3rd to 4th valve by the govenor pressure exceeds that exerted on the opposite end by the throttle valve pressure and this spring pressure combined, the valve shifts and oil is allowed to pass to the front unit clutch pistons and the brake release piston of the front unit servo. This shift to 4th gear occurs at about 20 m.p.h. at light throttle. If the accelerator pedal is depressed further, the throttle valve pressure is increased; consequently the govenor pressure must be raised to a higher value before the shift can take place. This can be done only by raising the car speed. Therefore, by varying the throttle opening, the speed at which the shift from 3rd to 4th occurs can be varied within a wide range. At full open throttle, the shift is made at about 65 m.p.h.

In order to shift down from 4th to 3rd at speeds below 65 m.p.h., it is necessary that the force drive to throttle valve pressure and spring pressure combined exceed the pressure due to the govenor. Under these conditions oil pressure is cut off from the clutch pistons and brake release piston and directed to the brake applying piston; opening the throttle valve provides the necessary force on the shifting valve to accomplish this change from 4th to 3rd at speeds between 20 and 65 m.p.h.

The govenor really consists of two valves, one of which builds up pressure very rapidly while the other builds it more slowly. This results in a greater flexibility of control than is possible with a single stage govenor. Shifts between 1st and 2nd gear are actuated by that stage of the govenor in which the pressure is built up more rapidly, and shifts between 2nd and 3rd and 3rd and 4th make use of both stages.

The reduction in the creeping tendency may be explained as follows: When the car is at a standstill, with the shift lever in driving position and the engine idling, the transmission is in 1st gear. The only reason the car is not moving (if the brake is released) is that the fluid coupling at the low speed of the engine does not produce sufficient torque to set the car in motion. The torque transmitted by the fluid coupling of the hydramatic drive is very low because with the transmission in 1st gear, the impeller of the coupling turns at only about 7 times the crankshaft speed and, as the torque of the speed, it is only about 1/2 what it would be if the coupling were driven directly from the crankshaft.

An important advantage of the fluid coupling in the transmission is that it will even out torsional disturbances.

The front unit brake band is now applied by oil pressure instead of by spring pressure.

The rear unit band is actuated by a combination of spring and oil pressure. It is applied and held by spring and oil pressure and released by oil pressure.

In the clutch mechanism there are now six pistons instead of three.

Another innovation is the use of hydraulic govenor driven by the output shaft of the transmission.

CADILLAC'S NEW HYDRAMATIC TRANSMISSION

Cadillac's new hydramatic transmission is the same as Oldsmobile transmission. It may be recalled that a hydramatic is a 4 speed transmission employing planetary gear units, combined with a fluid coupling which is used in combination with a low reduction rear axle. It is completely automatic, eliminating the clutch pedal and gear shift lever, and the need for their operation. It eliminates jerky starts, quiets the engine by lowering its speed of operation, and damps out vibration and shock. Acceleration and hill climbing ability are increased, and the car is said to have better traction on slippery surfaces. The automatic transmission is claimed to reduce fuel and oil consumption and wear and tear on the engine.

The direct design difference is that the intermediate planetary unit located substantially at the center of the housing is a 2 step instead of a single step reduction gear.

The manual control consists of a small lever and indicator mounted on top of the steering column beneath the steering wheel. This indicator shows the positions: neutral, Hi, Lo, and reverse.

For all normal driving, the Hi position is used when the car is started in this position and the transmission shifts automatically through the four speeds. When set in Lo, 3rd and 4th speeds are locked out so that the transmission reamins in either 1st or 2nd gear, making it possible to use the engine as a brake when descending hills.

To start the car, the operator starts the engine with the gear selector in neutral, selects the direction by placing the selector lever in either reverse or hi position and then steps on the accelerator.

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