FUNDAMENTAL PRINCIPLES OF THE HYDRA-MATIC TRANSMISSION

CONTENTS OF THIS SECTION

PURPOSE OF A TRANSMISSION

The purpose of a transmission is to provide suitable gear ratios between the engine and rear wheels for all driving conditions. Gear ratios are obtained through planetary gears in the Hydra-Matic transmission.

PLANETARY GEAR TRAIN

A planetary gear train (Fig. 3) consists of three members:

1. A center or "sun" gear.

2. A planet carrier with three or four planet pinion gears.

3. An internal gear.

The center or "sun" gear is surrounded by and meshes with the planet pinion gears, which rotate freely on pins attached to a common bracket called the "planet carrier." A ring with teeth machined on the inside circumference surrounds the assembly and meshes with the planet pinion gears. This is called the "internal" gear, because of its internal teeth.

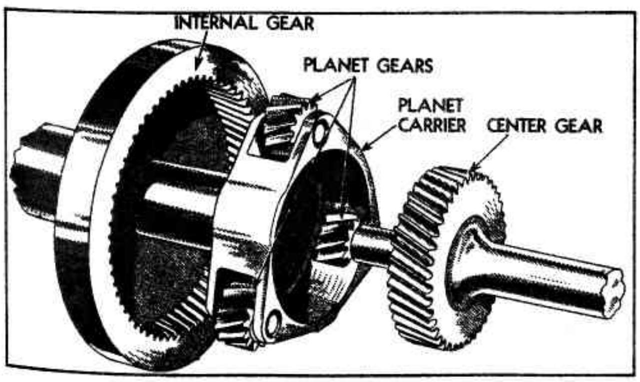

Fig. 3 Planetary Gear Train—Exploded

ADVANTAGES OF A PLANETARY GEAR TRAIN

1. A planetary gear train is compact and sturdy because the load is distributed over several gears instead of only two as in the sliding gear type of gear train. While planetary gears are smaller and occupy less space, they can transmit more tooth load because there is more tooth area in contact at all times.

2. Planetary gears are always completely in mesh, thus there is no possibility of tooth damage due to gear clash or partial engagement.

3. The common axis for all members of the planetary train makes the unit more compact and facilitates its use as a coupling when any two of its members are locked together.

OPERATION OF A PLANETARY GEAR TRAIN

1. A planetary gear train can be used to increase power and decrease speed in either of two ways.

a. One method of obtaining speed reduction (power multiplication) is to hold the internal gear stationary while power is applied to the center gear (Fig. 4). As the center gear turns, the planet pinion gears, which are in mesh with it, rotate on their respective pins. Since they are also in mesh with the stationary internal gear, they must "walk around" inside the internal gear, carrying the plant carrier with them in the same direction of rotation as the center gear. The planet carrier then rotates at a speed less than that of the center gear, and the planetary gear train functions as a power-increasing, speed-reducing unit.

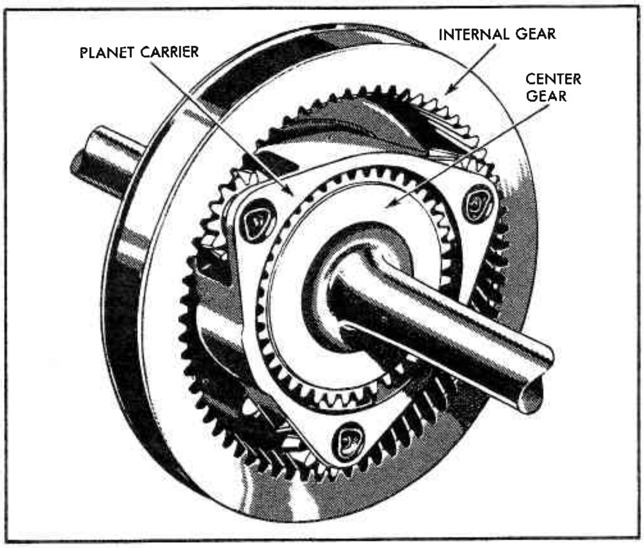

Fig. 4 Planetary Gears

b. The same result can be obtained by holding the center gear stationary and applying power to the internal gear. In this case, rotation of the internal gear causes the planet pinion gears to rotate on their respective pins and at the same time "walk around" the center gear, thus rotating the plant carrier at a speed less than that of the internal gear, and making the gear train function as a power-increasing, speed-reducing unit.

2. A planetary gear train can be used to reverse direction of rotation when the plant carrier is held stationary. In this instance, if power is applied to the center gear, the planet pinion gears rotate on their respective pins; but since the carrier is stationary, they act merely as idlers, transmitting power to the internal gear and causing it to rotate in the opposite direction.

In all of the examples described, one member has been held stationary, the power applied to another member, and taken off the third member.

3. A planetary gear train can be used to function as a coupling for direct mechanical drive when any two members are locked together.

Under this condition no movement can take place between the gears and the entire gear train will rotate as a unit.

4. When no member is held and no two members are locked together the planetary gear train will not transmit power, therefore it is in neutral.

FLUID COUPLING

A fluid coupling is employed in the Hydra-Matic Drive to relieve the driver of operating a clutch pedal and to cushion the shifts.

The fluid coupling consists of two parts called "torus members" splined to independent shafts and located in a fluid-filled housing consisting of a fly-wheel and torus cover.

The principal parts of each torus member (Fig.5) are, the shell, hub, and vanes interconnecting these shells. The two members are identical in construction except for the hubs which are different in size to fit their respective shafts.

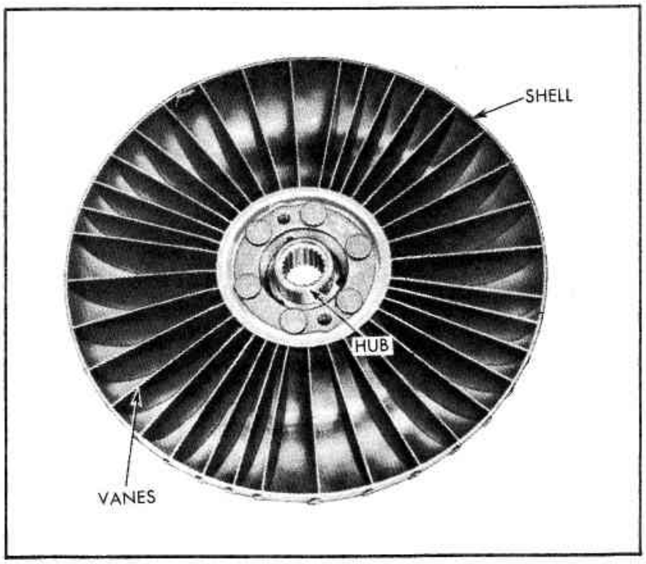

Fig. 5 Torus Member

A schematic cross section of two torus members attached to independent shafts and located in a fluid-filled housing is illustrated in Fig. 6. The shape of the compartment formed by the vanes is shown shaded.

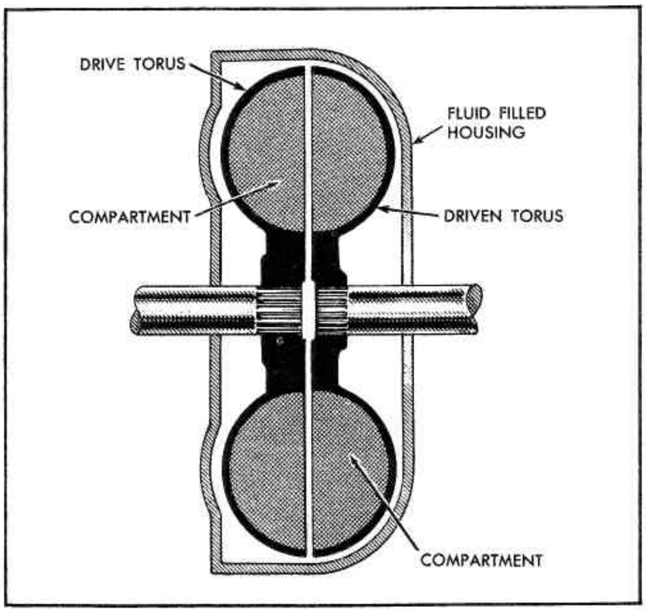

Fig. 6 Torus Members in Housing

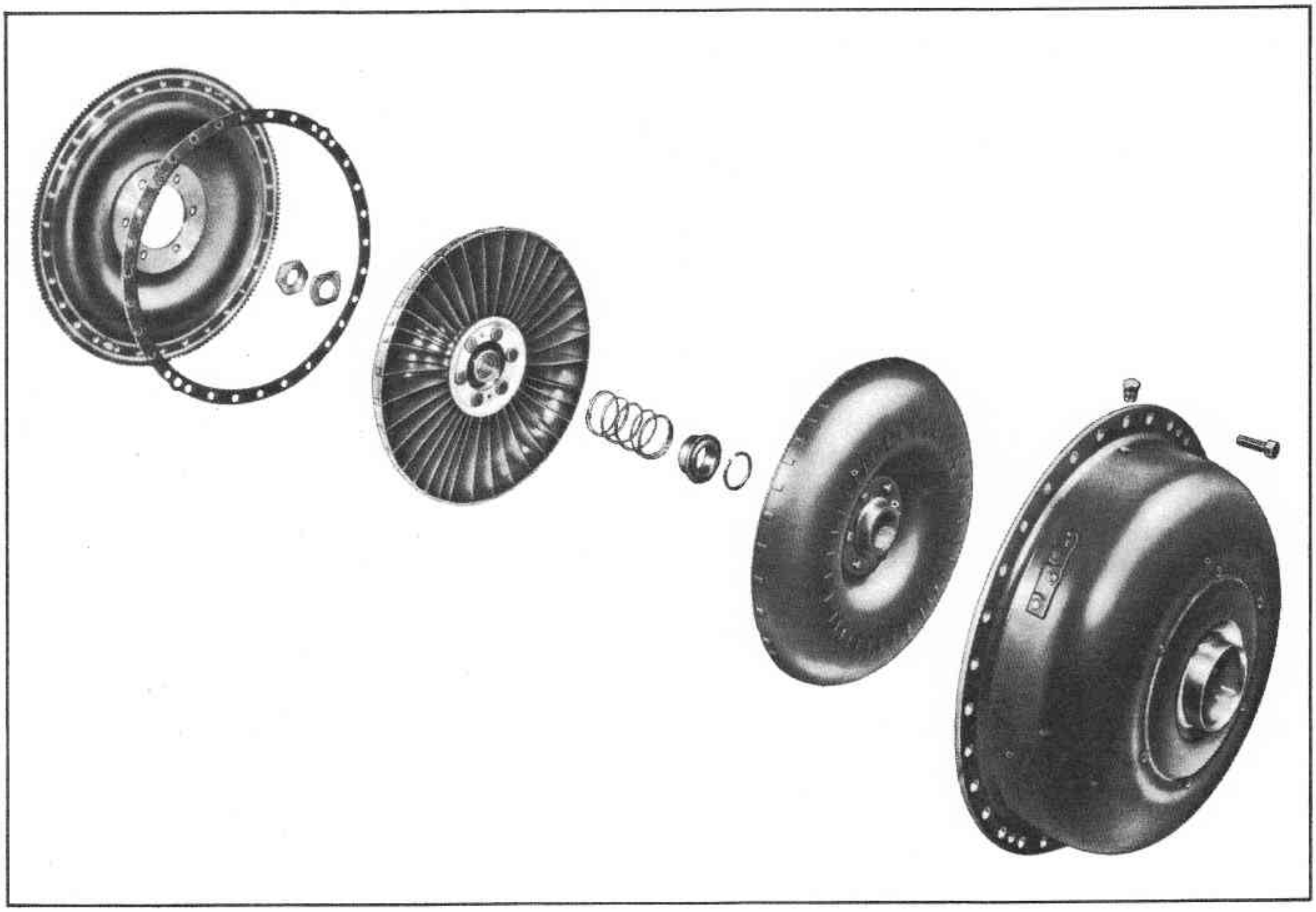

Fig. 7 Fluid Coupling Units

NOTE: An actual illustration of the component parts which make up the fluid coupling is shown in Fig. 7.

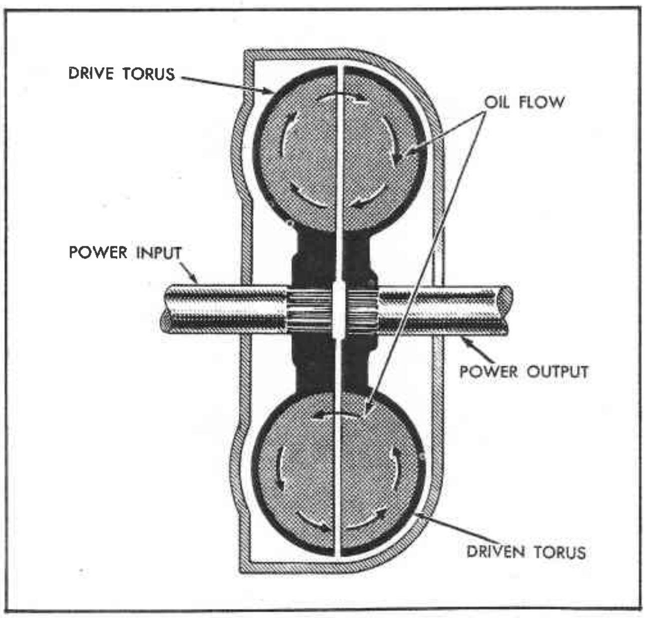

Fig. 8 Torus Members in Operation

In operation, rotation of the drive torus member causes the fluid within that member to be forced radially outward. Fluid then crosses over and strikes the vanes of the driven torus member, causing it to rotate in the same direction as the drive member (Fig. 8).

The higher the speed of the drive member, the greater the force exerted by the fluid on the driven member due to centrifugal action. Consequently, a fluid coupling is:

Very effective at high speed.
Less effective at low speed.
Non-effective at idle speed.

Keep this latter point in mind. It will be referred to later.

HYDRA-MATIC DRIVE COMPONENTS AND THEIR LOCATION

It is possible to obtain only two forward speeds, reduction and direct, from one planetary gear train or unit when applying power at the same source (for

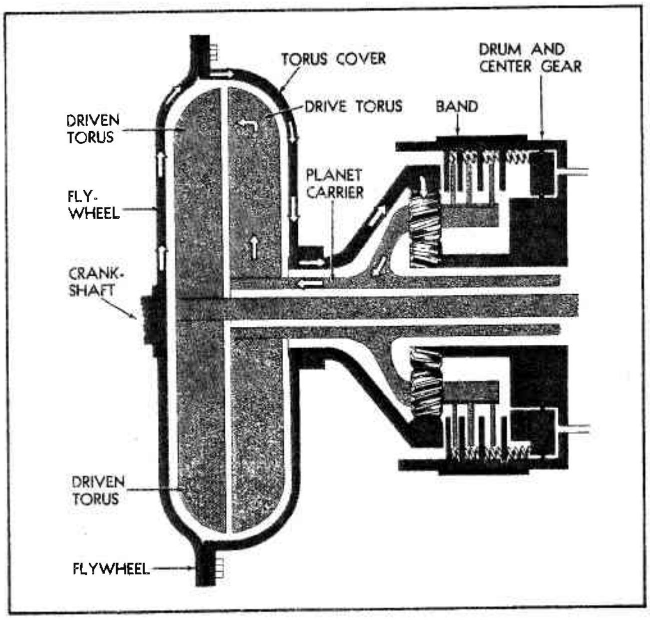

Fig. 9 Drive Torus Speed Reduction

example, the sun or center gear). As a greater variation of speed ratios is required to satisfactorily operate a vehicle, the Hydra-Matic transmission contains two planetary gear trains arranged to provide four speeds forward. This is accomplished by various combinations of bands and clutches. It also contains a third planetary gear train for reverse. In all forward speeds the reverse planetary unit has no function and simply revolves with the output shaft.

While the torus members are actually located in front of the transmission, they are in effect between the front and rear planetary units. This is due to the fact that the drive torus is splined on the front unit planet carrier and the driven torus is splined on the main shaft, which includes the rear planetary unit center gear.

DRIVE TORUS SPEED REDUCTION

When the car is standing, with the engine running and the control lever in DR, or Reverse, the drive torus turns at .65 engine speed. This reduction in the front unit makes possible an engine idle of 400 RPM without the car "creeping" forward. When the transmission shifts to second speed, the drive torus turns at engine speed since the front unit is in direct drive.

Power travels from the flywheel to the torus cover (Fig. 9) through the front planetary, which is in reduction because the band is applied, and then to the rear torus. The rear torus in the Hydra-Matic Drive is the drive member, while the front torus is the driven member.

As the vehicle starts, power travels from the flywheel to the torus cover through the front planetary in reduction, then through the fluid coupling and back to the rear planetary unit. When the speed of the vehicle has increased to a point where the reduction of the front planetary unit is no longer required, the front planetary shifts to direct drive and the drive torus turns at the same speed as the engine.

FUNDAMENTALS OF THE HYDRA-MATIC TRANSMISSION

In the Hydra-Matic transmission two planetary units are used to give four forward speeds (Fig. 10). In each unit a hydraulically operated clutch is used to lock two planetary members together for direct drive. Reduction (power multiplication) is obtained in both units by means of a band which can be used to hold one of the planetary units stationary. The bands are operated by means of hydraulically controlled servos.

Oil for hydraulic operation is supplied by two oil pumps. One oil pump (front pump) is driven by the engine and the other by the output shaft of the transmission.

Although both planetary units are similar, the rear unit differs in two ways from the front unit.

1. It is longer, has more clutch plates and greater gear reduction.

2. The rear servo is normally applied by spring pressure and released by oil pressure.

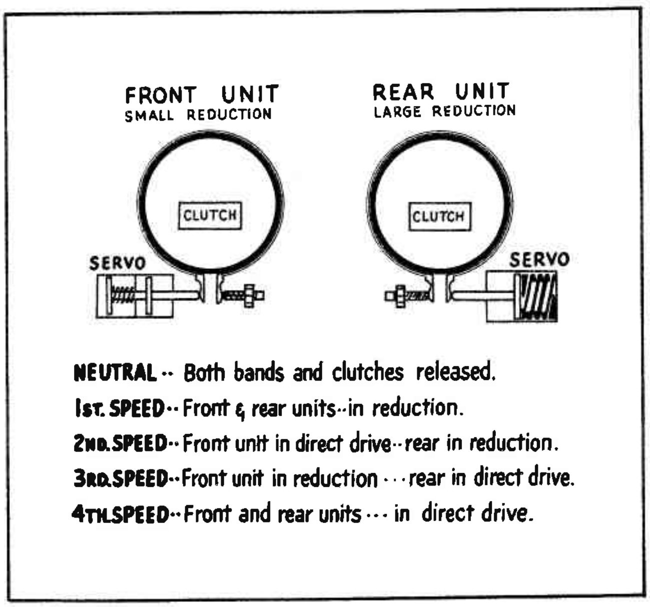

Fig. 10 Band and Clutch Positions in Different Gears

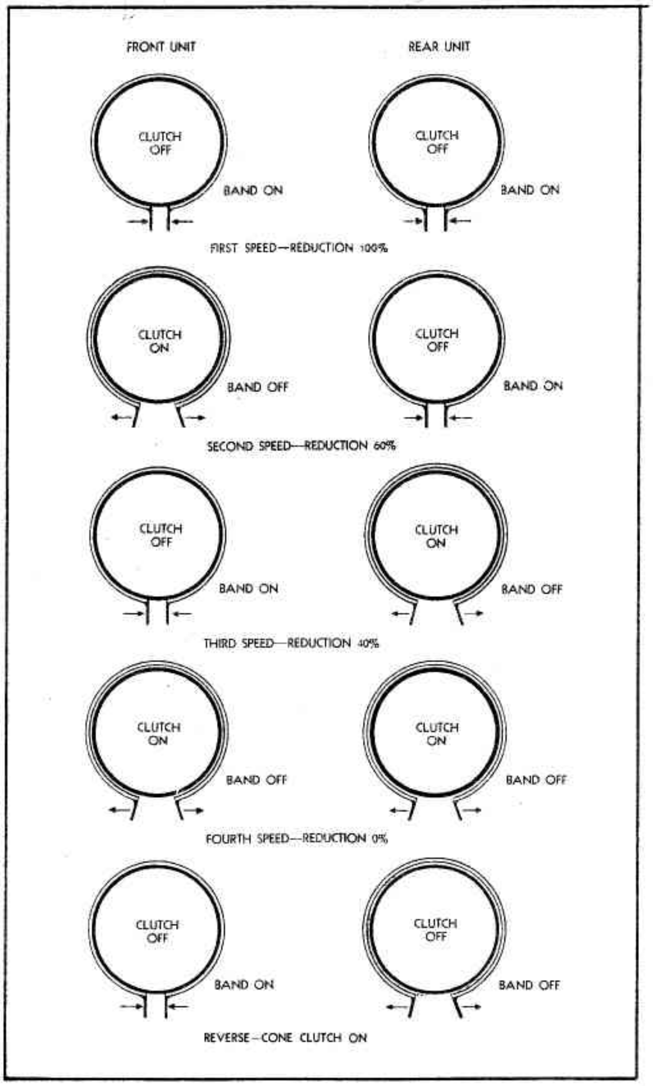

Fig. 11 Band and Clutch Application

IMPORTANT

Knowledge of clutch and band application (Fig. 11) is basic and must be acquired by anyone who is to understand Hydra-Matic transmission operation and who wishes to become expert in trouble diagnosis.

MEMORIZE

Memorize band and clutch application for the four forward speeds. The following example is given as one way this can be done.

Example

The greatest forward speed reduction will be wanted in first speed—call this 100% reduction.

The next greatest reduction will be wanted in second speed—call this approximately 60% reduction.

The next greatest reduction will be wanted in third speed—call this approximately 40% reduction.

In fourth speed, direct drive is wanted—call this 0% reduction.

For simplicity in this example, the front unit will be considered capable of giving 40% reduction and the rear unit 60% reduction. The two units then can be used in various reduction and direct drive combinations to provide four speeds forward and reverse.

REMEMBER

In either planetary unit of the Hydra-Matic transmission:

—When the band is applied the clutch is disengaged and the unit is in reduction.

—When the clutch is applied the band is disengaged and the unit is acting as a coupling for direct drive.

REVIEW

Review clutch and band applications frequently. Ability to visualize "reduction" or "direct drive" in each unit for each forward speed is invaluable in diagnosing trouble.

POWER FLOW IN THE HYDRA-MATIC TRANSMISSION

POWER FLOW IN NEUTRAL—ENGINE RUNNING

The flywheel, torus cover, and the front drive gear (front unit internal gear) are all attached to each other and rotate at engine speed. Since the front drive gear is the internal gear of the front planetary unit its rotation causes the front unit planetary gears to rotate on their pins. Since no member of the front unit is held, no power is transmitted to the planet carrier and drive torus (Fig. 12).

POWER FLOW IN FIRST SPEED

When the vehicle starts to move, the path of power is through the flywheel to the torus cover and front drive gear (Fig. 12) to the front planet carrier. The front band is holding the front unit center gear, causing the planetary pinions to "walk around" the center gear, carrying the front planet carrier in the same direction as the internal gear but at reduced speed. Since the drive torus is connected to the front planet carrier it also turns at reduced speed. From the drive torus the power is transferred through

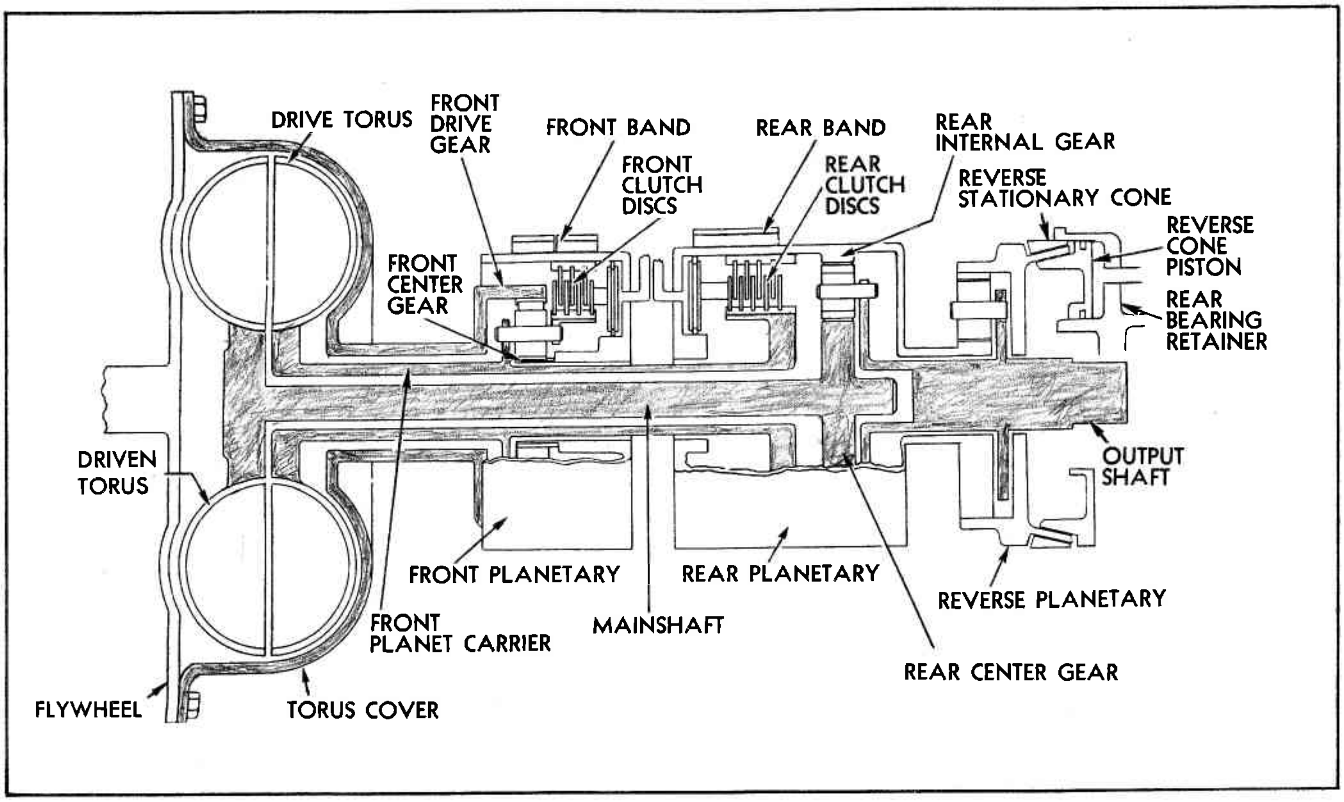

Fig. 12 Hydra-Matic Drive Components

fluid to the driven torus, then along the main shaft to the center gear of the rear planetary, then, through the planet pinions to the planet carrier on the output shaft in reduction because the internal gear of the rear unit is held stationary by the band.

POWER FLOW IN SECOND SPEED

Power travels from the flywheel to the torus cover, through the front planetary unit in direct drive, forward to and through the fluid coupling, then back along the main shaft through the rear planetary which is in reduction, to the output shaft (Fig. 12).

POWER FLOW IN THIRD SPEED

Power travels from the flywheel to the torus cover, then through the front unit in reduction. Power coming from the front unit is split in two directions. Part of it goes forward, driving the fluid coupling and the mainshaft which is splined to the driven torus. The other part goes back the intermediate shaft to the rear unit.

With the rear unit clutch applied, the rear unit internal gear is locked to the intermediate shaft. Thus, since both the rear unit internal gear and the rear unit center gear are being driven by the front unit at the same speed they are in effect locked together. Therefore, the rear unit is in direct drive and the rear planetary and output shaft turn at the same speed as the planetary of the front unit, which is an integral part of the intermediate shaft (Fig. 12).

POWER FLOW IN FOURTH SPEED

The path of power is exactly the same as in third speed except that it passes through the front planetary in direct drive instead of reduction. The same division of power applies in fourth speed as in third. Thus the fluid coupling is relieved of engine power which results in a more efficient drive (Fig. 12).

POWER FLOW IN REVERSE

Power travels from the flywheel and torus cover through the front planetary in reduction to the fluid coupling, then along the main shaft to the center gear of the rear planetary. The clutch and band of the rear planetary are released and the planet carrier is held by the propeller shaft. The planet pinion gears then act as idlers and the rear unit center gear turns the internal gear in the opposite direction. The internal gear through a flange, drives the center gear of the reverse unit in a reverse direction. Power then travels through the reverse planetary to the output shaft (which is also the planet carrier of the rear unit) in reduction because the internal gear is held by the reverse cone clutch (Fig. 12).

HYDRAULIC ACTION IN THE HYDRA-MATIC TRANSMISSION

The following schematic oil flow diagrams cover the hydraulic action in the 1955 Hydra-Matic transmission.

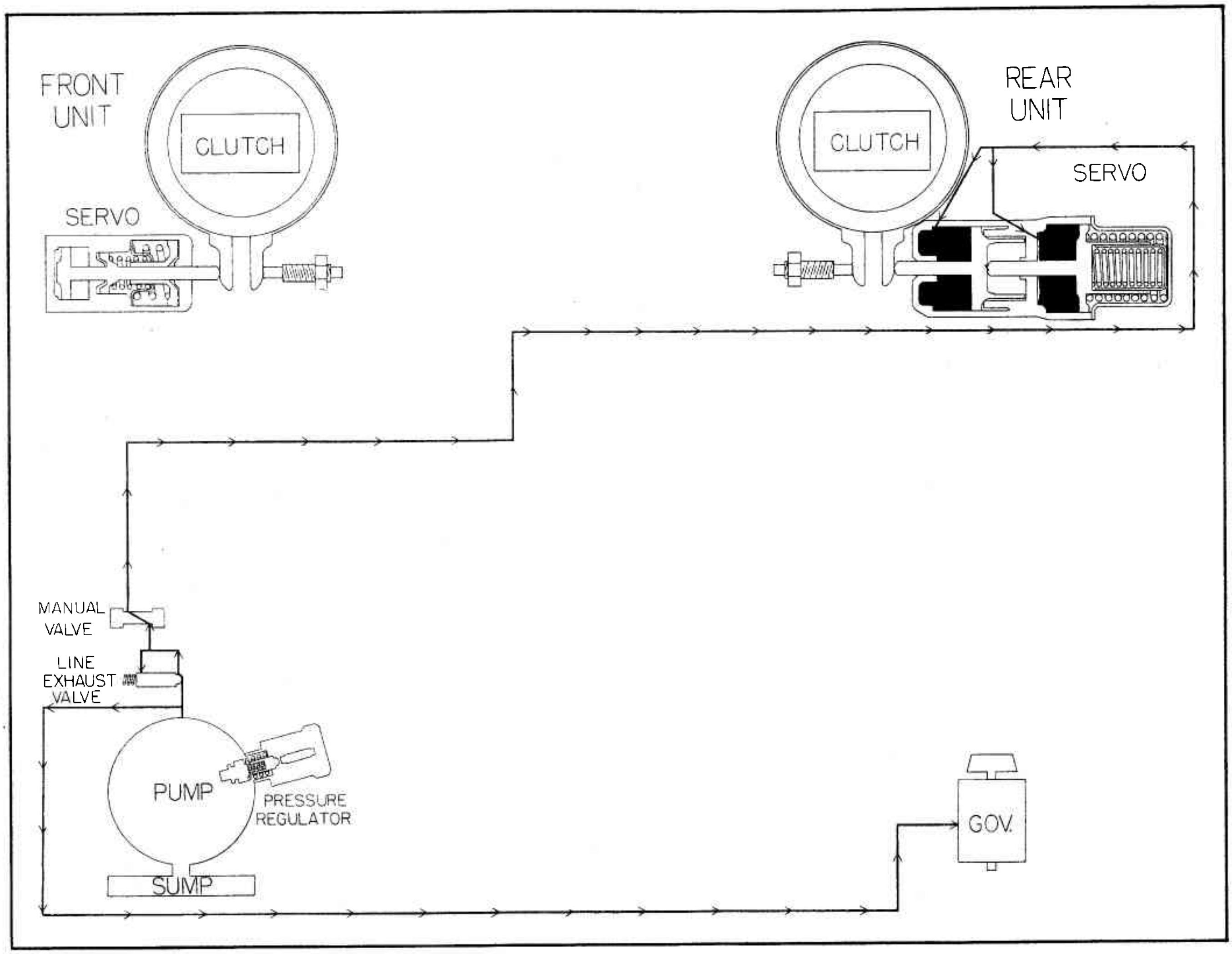

Fig. 13 Hydraulic Action in Neutral—Engine Running

NEUTRAL

CAR STANDING, ENGINE NOT RUNNING

Since the transmission oil pumps are not operating, no oil pressure exists within the transmission; therefore, the main line exhaust valve spring holds the valve open to exhaust and the front servo and front and rear clutch plates are released by their respective springs.

The rear servo is applied by spring pressure thus engaging the rear band.

SUMMARY: Car standing, engine not running.
Front band released – front clutch released.
Rear band applied—rear clutch released.

NEUTRAL

CAR STANDING, ENGINE RUNNING

After the engine is started, the front pump builds up oil pressure, closing the main line exhaust valve and supplying oil to the manual valve and governor. The manual valve directs oil to the rear servo and releases the rear band. Since oil is not directed to the front servo or the front or rear clutch units, they remain in the released position. Thus both bands and clutches are now released and the transmission is in neutral.

SUMMARY: Neutral, engine running.
Front band released—front clutch released.
Rear band released—rear clutch released.

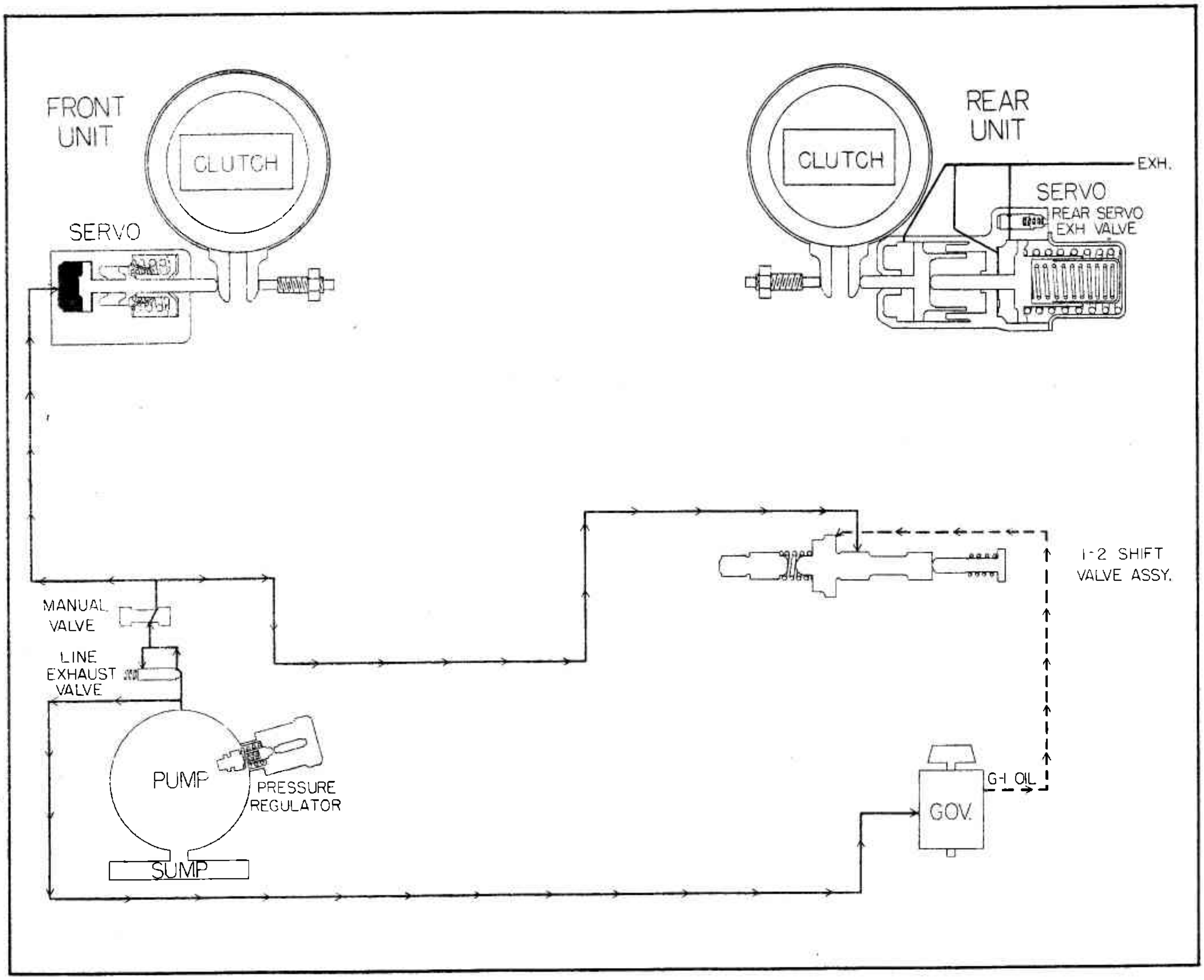

Fig. 14 Hydraulic Action in First Speed

FIRST SPEED

SELECTOR LEVER IN EITHER DRIVE POSITION

When the selector lever is in either DR position, the manual valve shuts off the oil to rear servo allowing rear servo springs to apply rear band. At the same time oil is directed to front servo to apply front band. Oil is not directed to the front and rear clutches and they will, therefore, be released by spring pressure.

The rear servo exhaust valve is held open by spring pressure. This allows servo release oil to exhaust rapidly giving a quicker application of the rear band when shifting from neutral or reverse to a drive range.

Oil is also directed from the manual valve to the shift valves, but it is blocked since the shift valves are held closed by the shift valve springs.

When the car is in motion the output shaft drives the governor causing it to rotate. Oil passing through the governor (governor oil) is directed to the shift valve.

SUMMARY: Both units in reduction.

Front band on—front clutch released.

Rear band on—rear clutch released.

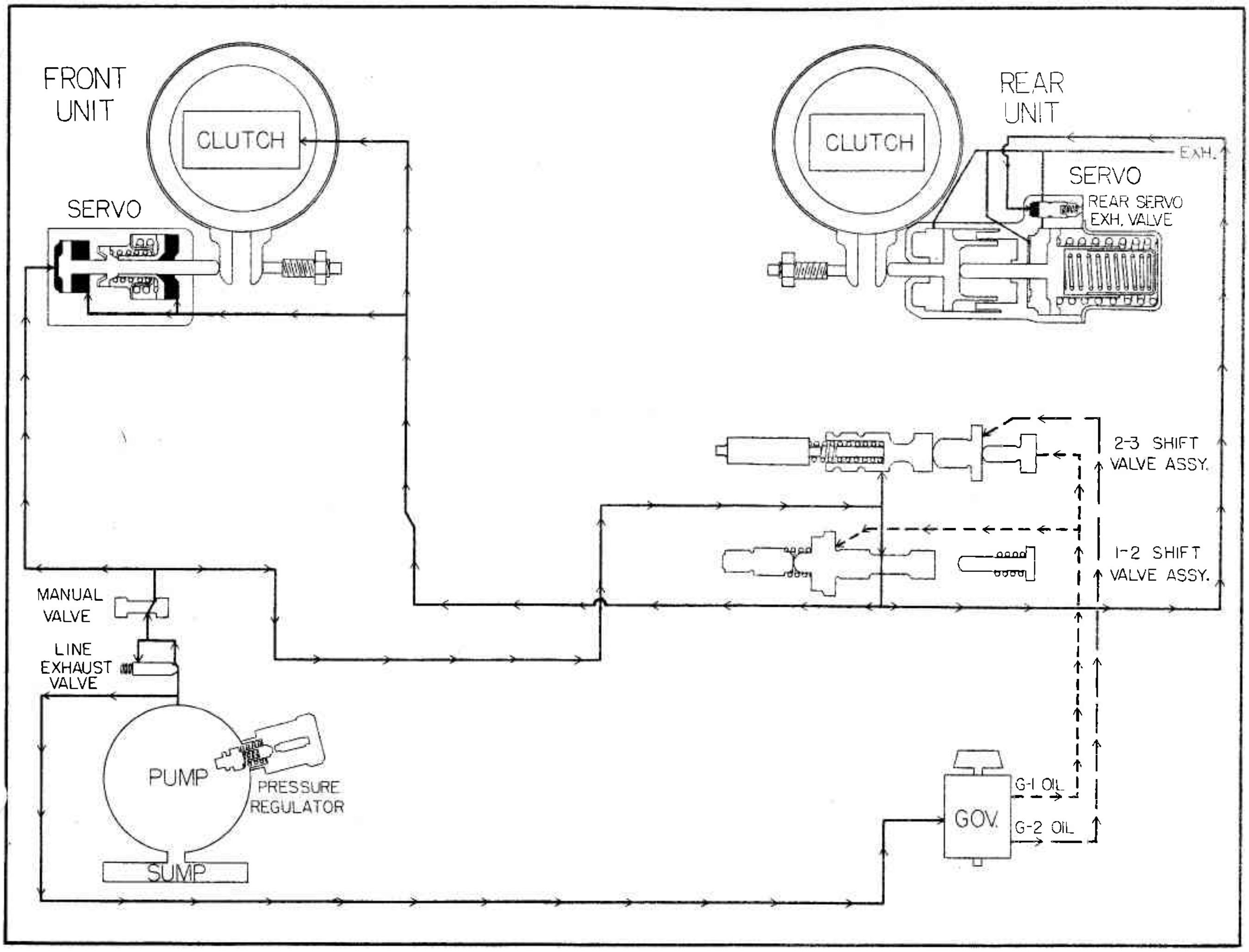

Fig. 15 Hydraulic Action in Second Speed

SECOND SPEED

SELECTOR LEVER IN EITHER DRIVE POSITION

Governor oil is used to move the shift valves to their open position automatically in relation to car speed. The governor has two valves, one of which is heavier than the other. Due to centrifugal force the heaviest valve, which is the G-1 valve, opens first and regulates G-1 oil pressure. The light valve is called the G-2 valve and regulates G-2 oil pressure. The valves allow both oil pressures to increase with car speed.

As the car gains speed, G-1 oil pressure acting on the 1-2 shift valve will increase and open the shift valve against spring force. Main line oil will then be allowed to go past the 1-2 shift valve to release the front band and apply the front clutch.

Main line oil passing the 1-2 shift valve also moves the rear servo exhaust valve against spring force to the closed position.

Front band release is accomplished even though apply oil pressure still exists, because the release oil is directed back of the apply piston as well as to the release piston. This allows release oil to work on a greater area, hence, the release force overcomes the apply force and the band is released. At the same time main line oil is applied to the front clutch.

SUMMARY: Front unit in direct drive, rear unit in reduction.
Front band off—front clutch on.
Rear band on—rear clutch off.

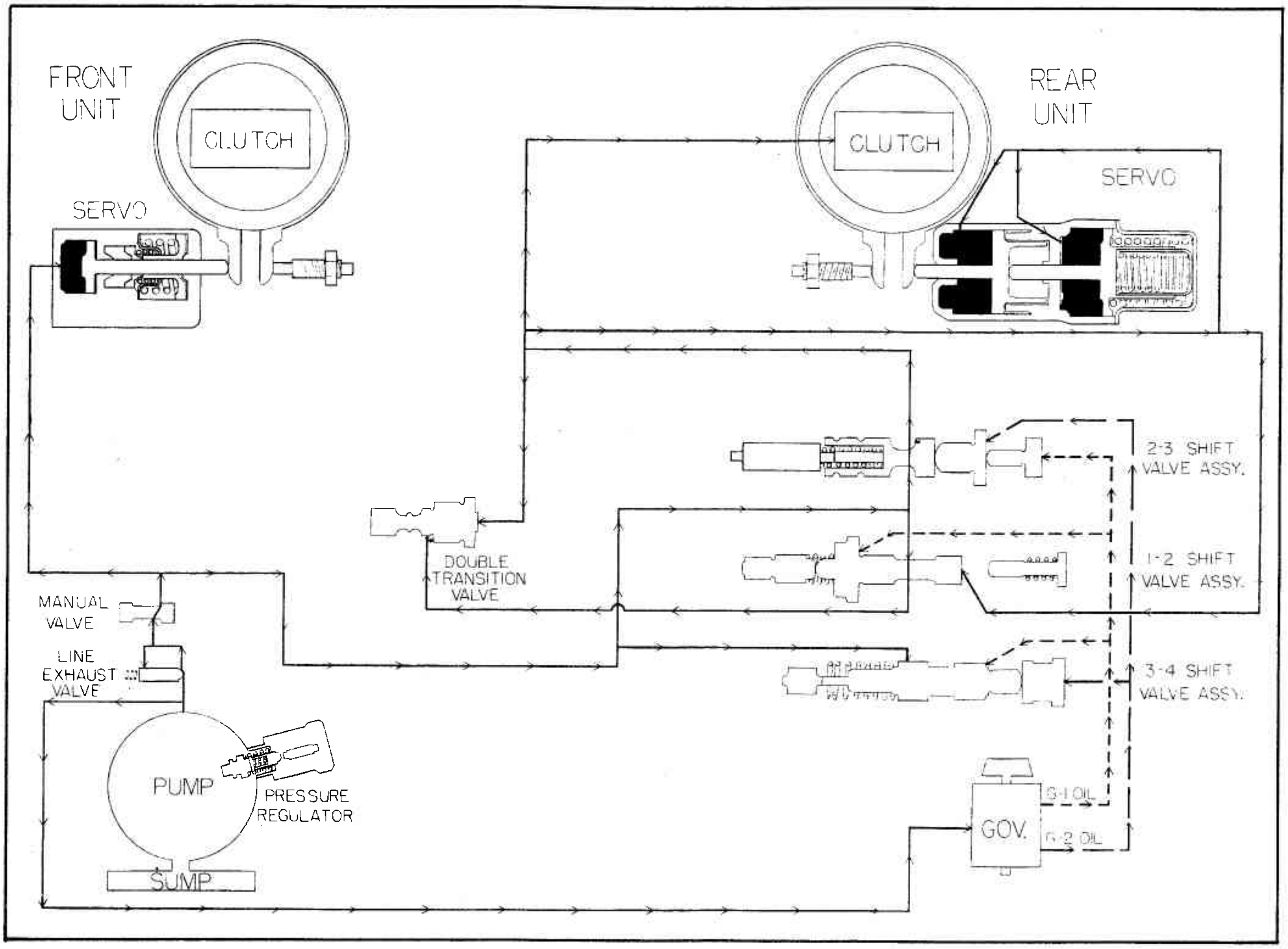

Fig. 16 Hydraulic Action in Third Speed

THIRD SPEED

SELECTOR LEVER IN DRIVE LEFT POSITION

G-1 governor oil pressure is applied to 2-3 governor plug; G-2 governor oil pressure to 2-3 auxiliary valve—governor oil pressures will increase with car speed and open the 2-3 shift valve by overcoming the 2-3 shift valve spring force. Main line oil from the 2-3 shift valve then closes the double transition valve, shutting off front clutch apply oil and front band release oil. The front clutch will then be released by springs and main line oil will apply the front band.

Oil passing through the 2-3 shift valve is also directed to rear servo to release rear band and to rear clutch unit to apply the clutch, and to the 1-2 shift valve.

SUMMARY: Front unit reduction, rear unit direct drive.
Front band on—front clutch off.
Rear band off—rear clutch on.

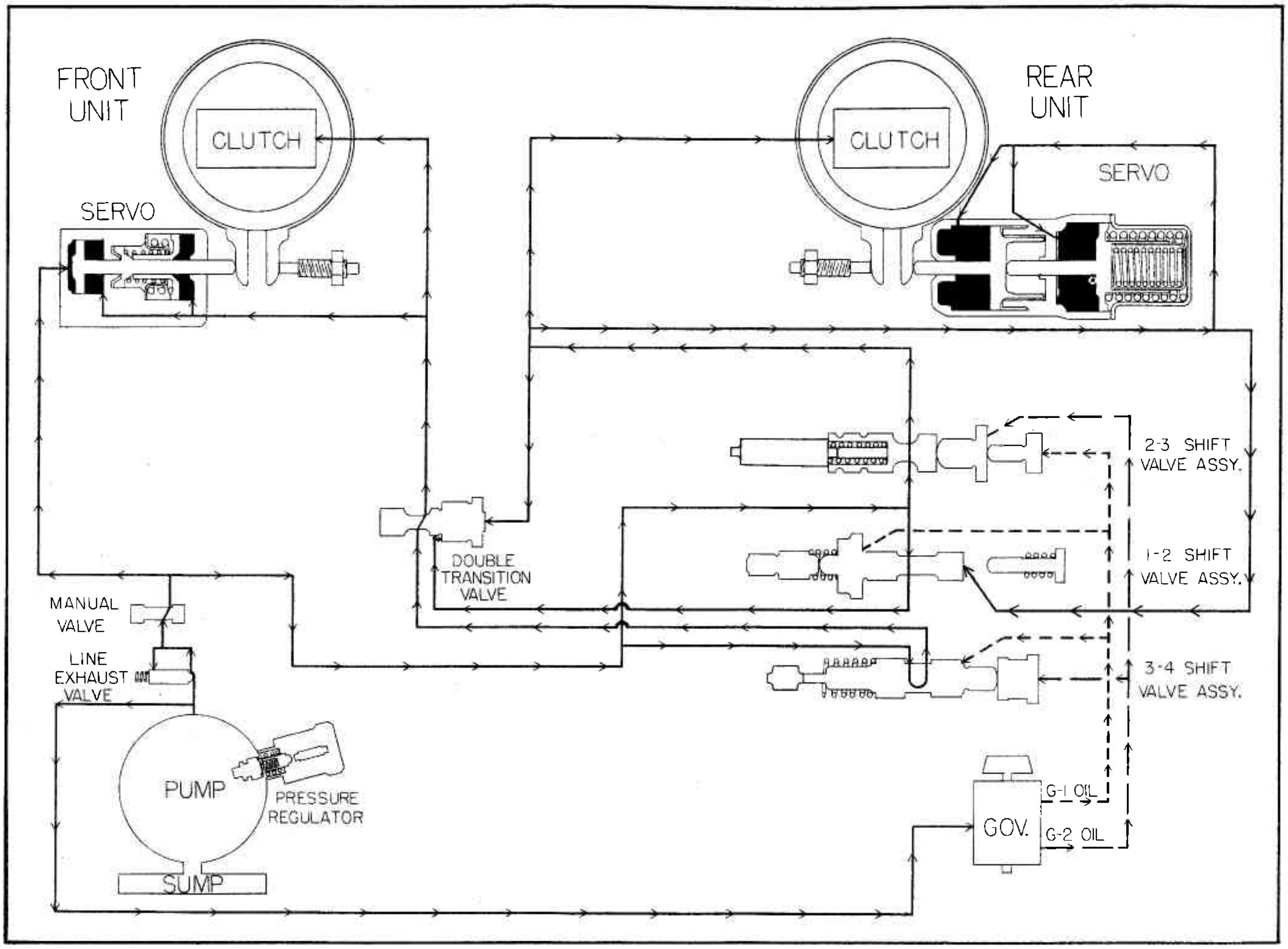

Fig. 17 Hydraulic Action in Fourth Speed

FOURTH SPEED

SELECTOR LEVER IN DRIVE LEFT POSITION

G-1 governor oil pressure is applied to the 3-4 shift valve; G-2 governor oil pressure is applied to the 3-4 governor plug — governor pressures will increase with car speed and open the 3-4 shift valve by overcoming the 3-4 shift valve spring force. Main line oil will then be directed through the 3-4 shift valve past the double transition valve to release the front band and apply the front unit clutch. This places the front unit in direct drive; since the rear unit was already in direct drive the transmission will be in fourth speed.

SUMMARY: Front and rear units are in direct drive.
Front band off—front clutch on.
Rear band off—rear clutch on.

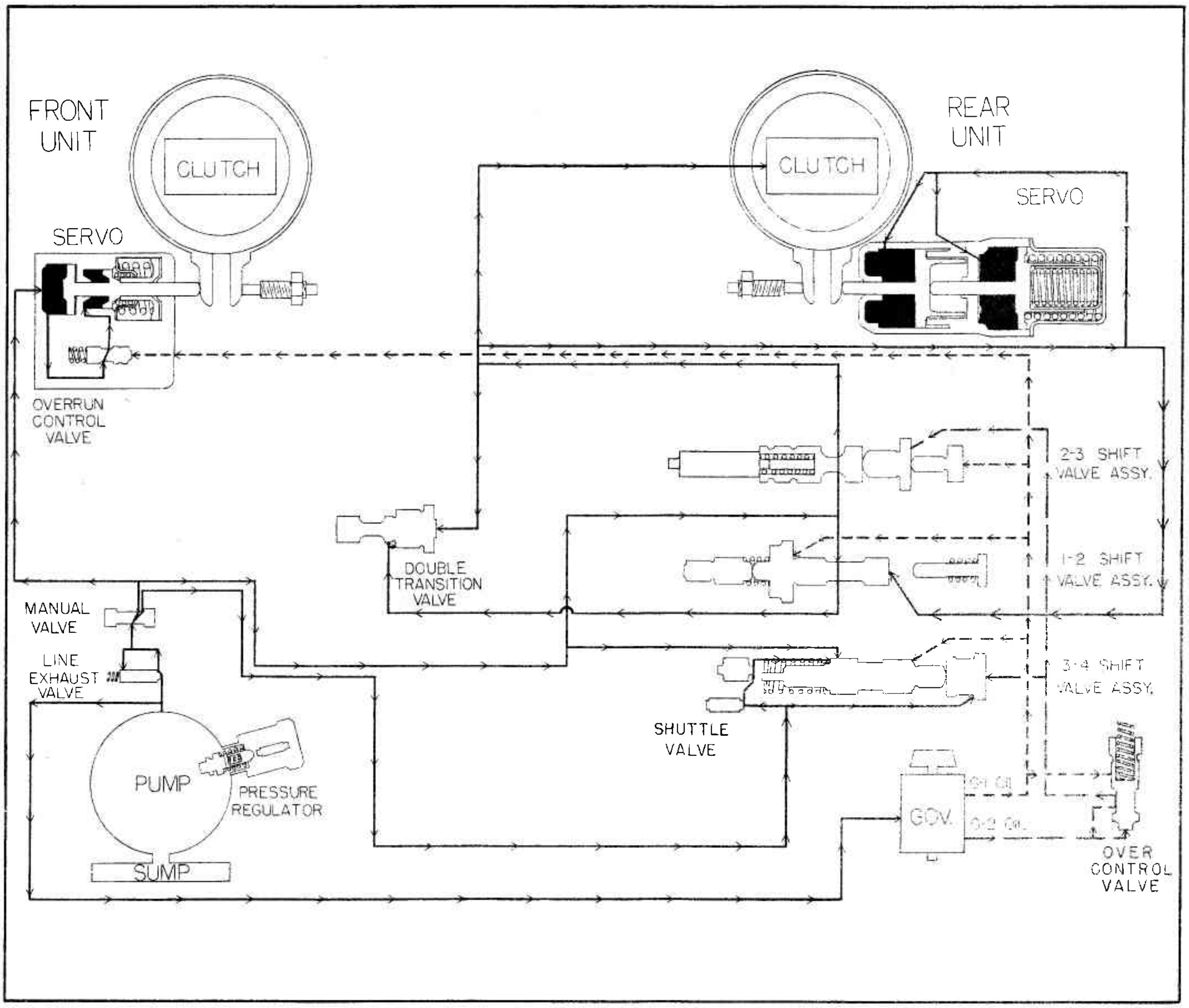

Fig. 18 Hydraulic Action in Third Speed—Drive Right Range

THIRD SPEED

SELECTOR LEVER IN DRIVE RIGHT POSITION

When the manual valve is in the drive right position main line pressure is directed behind the 3-4 governor plug to oppose governor pressure and to the 4-3 shuttle valve. Pressure against the end of the shuttle valve opens it to direct main line pressure against the back of the 3-4 shift valve.

Main line pressure behind the 3-4 shift valve and governor plug then overcomes governor pressure, preventing the shift valve from opening, or closing the shift valve if it is open. Thus the transmission cannot shift into fourth speed.

When car speed is above 20 MPH G-1 oil pressure moves the front servo overrun control valve to allow main line oil to act on the compensator piston instead of compensator oil. This aids in preventing slippage of the front band when the car is coasting (throttle closed) and the engine is being used as a brake.

At speeds below approximately 70 MPH, G-2 oil cannot overcome the over control valve spring.

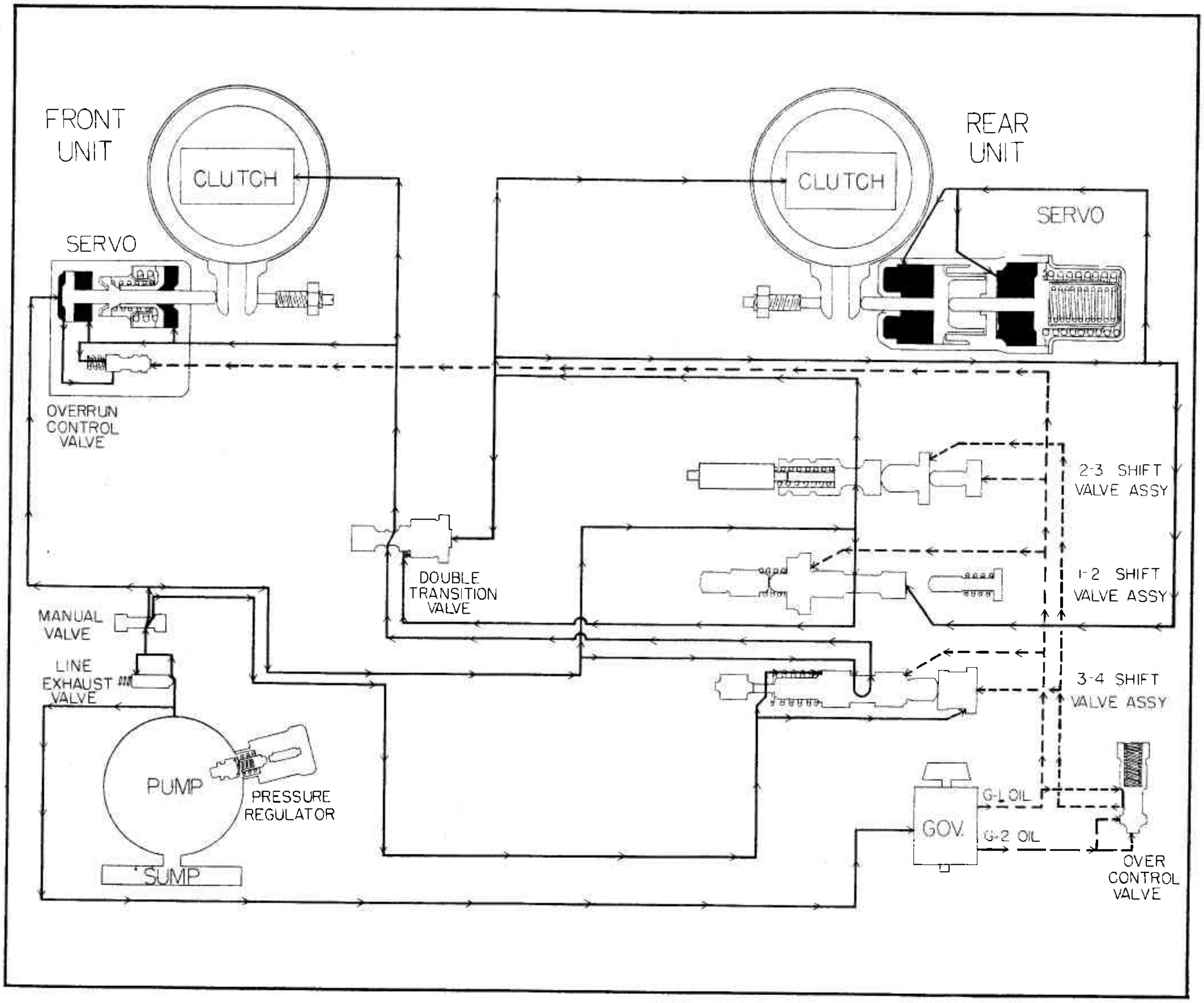

Fig. 19 Hydraulic Action in Fourth Speed—Drive Right Range

FOURTH SPEED

SELECTOR LEVER IN DRIVE RIGHT POSITION

When the manual valve is in the drive right position, below approximately 70 MPH, oil is directed as illustrated in Fig. 18.

Above approximately 70 MPH G-2 oil will close the over control valve, allowing G-1 oil to flow through G-1–G-2 oil passage. This additional oil pressure acts on the 3-4 governor plug and causes the transmission to shift into fourth speed.

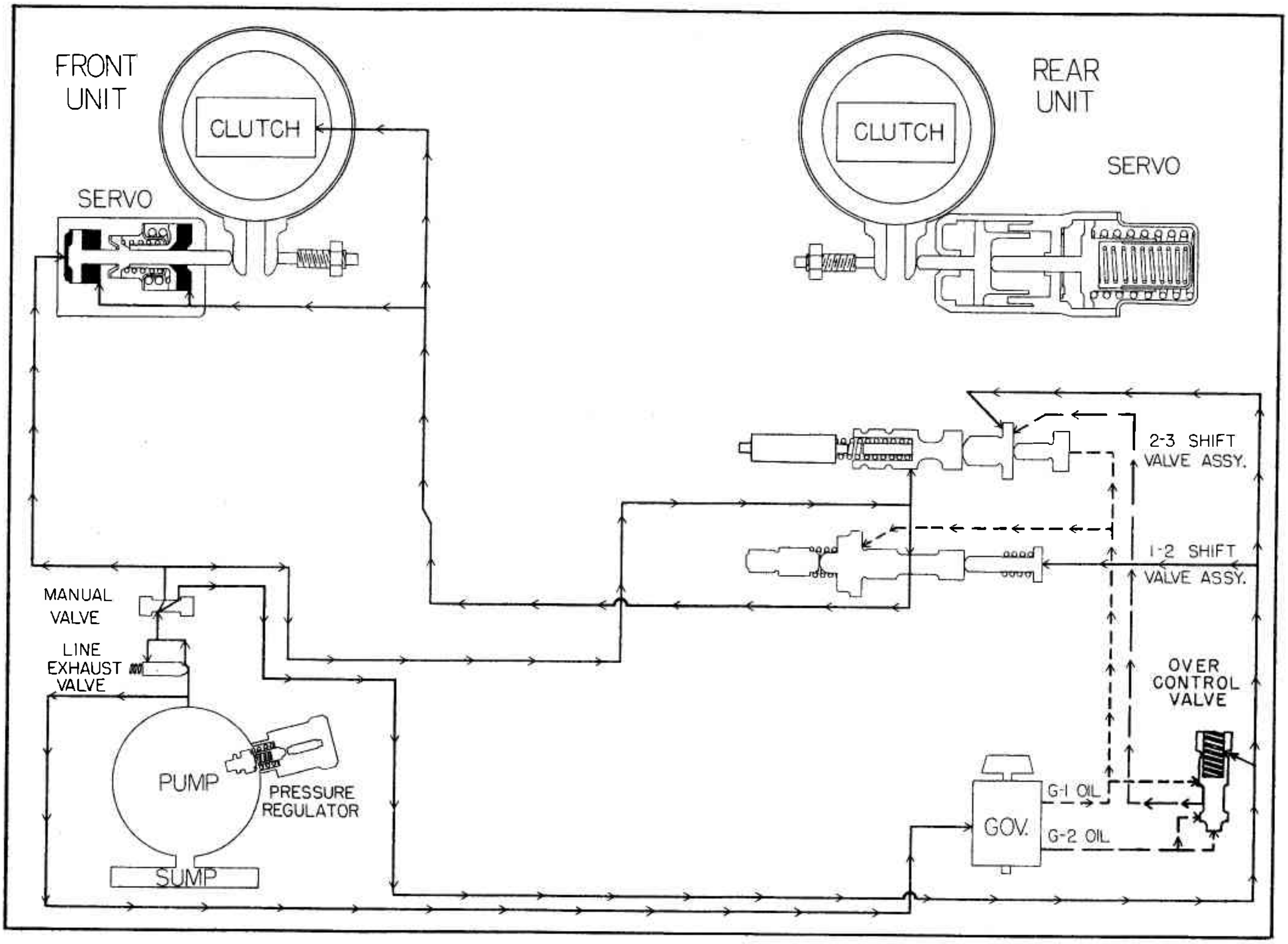

Fig. 20 Hydraulic Action in LO Range—Second Speed

LOW RANGE

SELECTOR LEVER IN LO POSITION

When the manual valve is in the low range position, main line oil against the 2-1 detent plug moves the 1-2 shift valve to the open position. This allows main line oil to pass through the 1-2 shift valve and release the front band and apply the front clutch, shifting the transmission to second speed.

At the same time main line oil is directed behind the 2-3 auxiliary valve to hold the 2-3 shift valve closed. This prevents governor oil pressure from causing a 2-3 upshift.

Above approximately 42 MPH, LO oil pressure acts on the larger diameter of the over control valve, thus assisting G-2 oil and opens valve against spring pressure. Both G-1 and G-2 oil then act on the 3-4 shift valve, thus completing the shift to fourth speed.

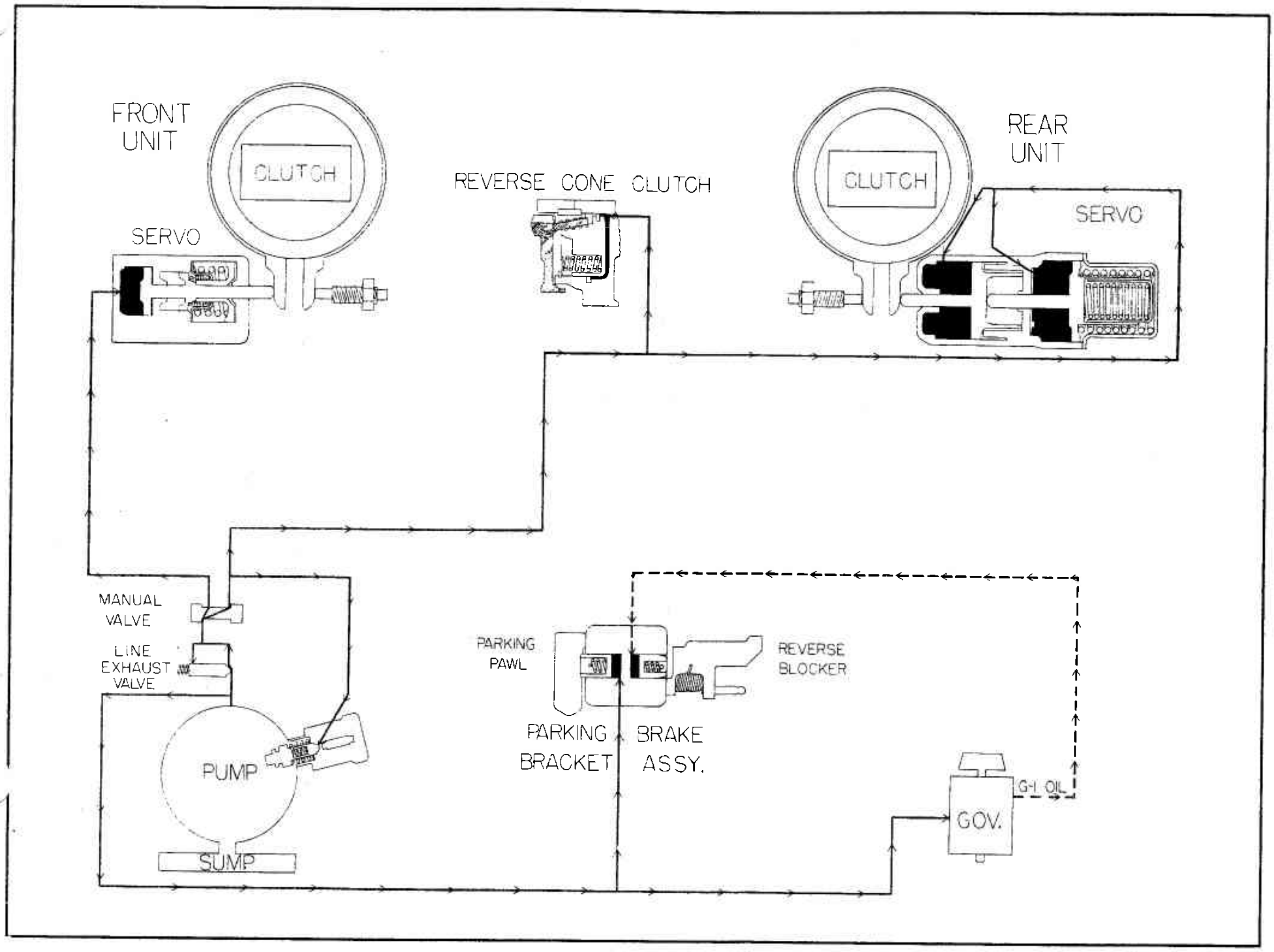

Fig. 21 Hydraulic Action in Reverse

REVERSE

When the selector lever is in the reverse position the manual valve directs main line oil to the following:

1. To the front servo to apply the band.

2. To the rear servo to release the band.

3. To the reverse cone clutch to hold the reverse internal gear.

4. To the reverse booster plug in the pressure regulator to give increased main line pressure.

G-1 governor oil pressure is directed to the reverse blocker piston to prevent shifting the transmission into reverse at speeds above 10 MPH.

When the engine is not running, reverse can be used as a parking brake by means of a parking pawl which holds the reverse internal gear. When the engine is running main line oil pressure behind the parking blocker piston will hold the parking pawl clear of the reverse internal gear for normal operation of reverse.

SUMMARY: Front unit in reduction, rear unit neutral, reverse unit engaged.

Front band on – front clutch off.

Rear band off – rear clutch off.

Reverse cone clutch engaged.

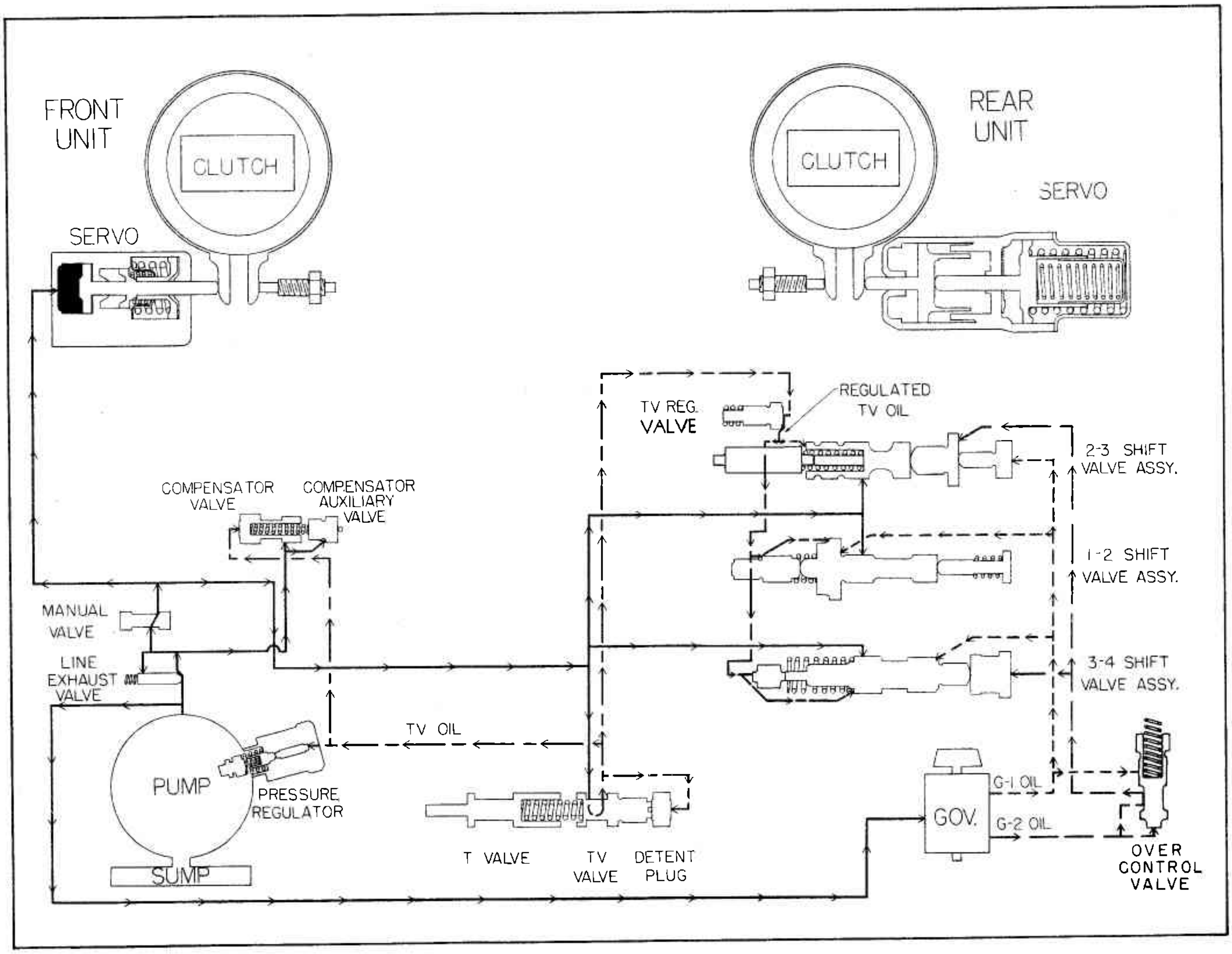

Fig. 22 Hydraulic Action of TV and Regulated TV Oil

TV OIL PRESSURE

When the accelerator pedal is depressed, the mechanical linkage to the transmission TV lever varies the position of the throttle valve assembly. In this way a variable oil pressure controlled by accelerator pedal position is obtained from the TV valve. This oil pressure, called throttle or TV oil pressure, is directed to the following:

1. To the TV plug in the pressure regulator assembly to regulate main line oil pressure.

2. To the compensator valve to give compensator oil pressure.

3. To the TV regulator valve to provide "Regulated TV Oil Pressure."

4. To the detent plug behind the throttle valve.

REGULATED TV OIL PRESSURE

The shifts would always occur at the same speeds if only the shift valves, shift valve springs, and governor oil pressure described on the preceding pages were used. This is undesirable since many circumstances arise which make it desirable to have the shift delayed until a higher car speed is reached. Automatic control of shifts in relation to car speed is obtained by means of regulated TV oil pressure.

Regulated TV oil pressure from the TV regulator valve is directed to the 2-3 shift valve, 1-2 regulator plug and shift valve, and 3-4 regulator plug and shift valve to aid the spring forces in holding the shift valves closed. Since regulated TV oil pressure varies with TV oil pressure, and TV oil pressure varies with throttle opening, the shifts will vary with throttle opening. As throttle opening is increased the car speed at which shifts will occur is increased.

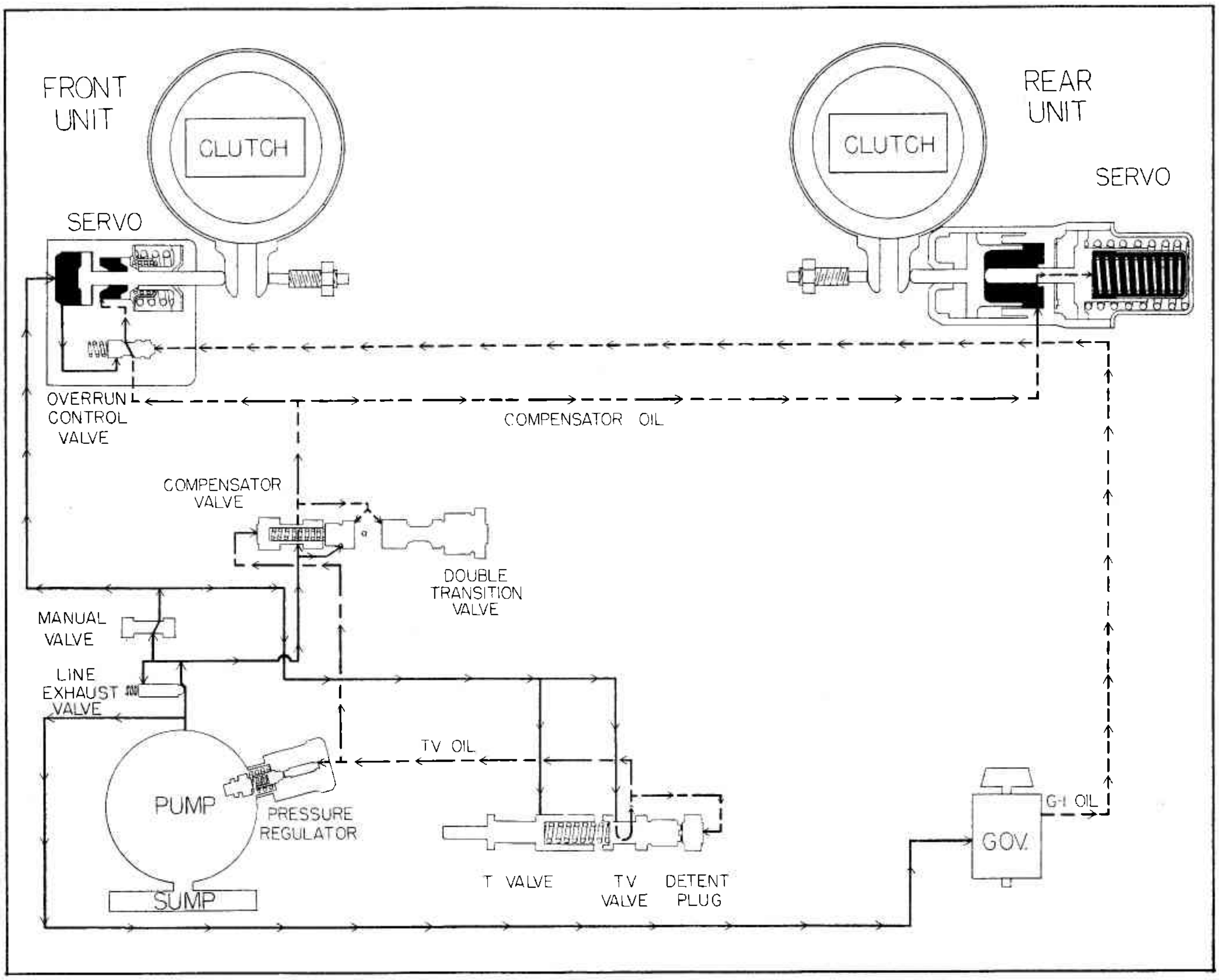

Fig. 23 Compensator Oil Pressure

COMPENSATOR OIL PRESSURE

The increased torque developed under rapid acceleration requires additional holding force to prevent the bands from slipping.

This force is obtained through the use of a compensator valve which directs a variable regulated oil pressure to both the front and rear servos.

The compensator valve is operated by TV oil pressure; therefore, the greater the accelerator pedal travel (giving greater TV oil pressure) the greater the resulting compensator oil pressure. Compensator oil also aids in repositioning the double transition valve on a full throttle downshift.

Compensator pressure to the front servo compensator piston must pass through the overrun control valve. The overrun control valve is controlled by governor pressure and spring force. At speeds less than 20 MPH spring force positions the valve so that compensator pressure acts on the compensator piston. At speeds over 20 MPH governor pressure overcomes spring force, moving the valve so that main line pressure is directed against the compensator piston rather than compensator pressure. (See illustration page 18.)

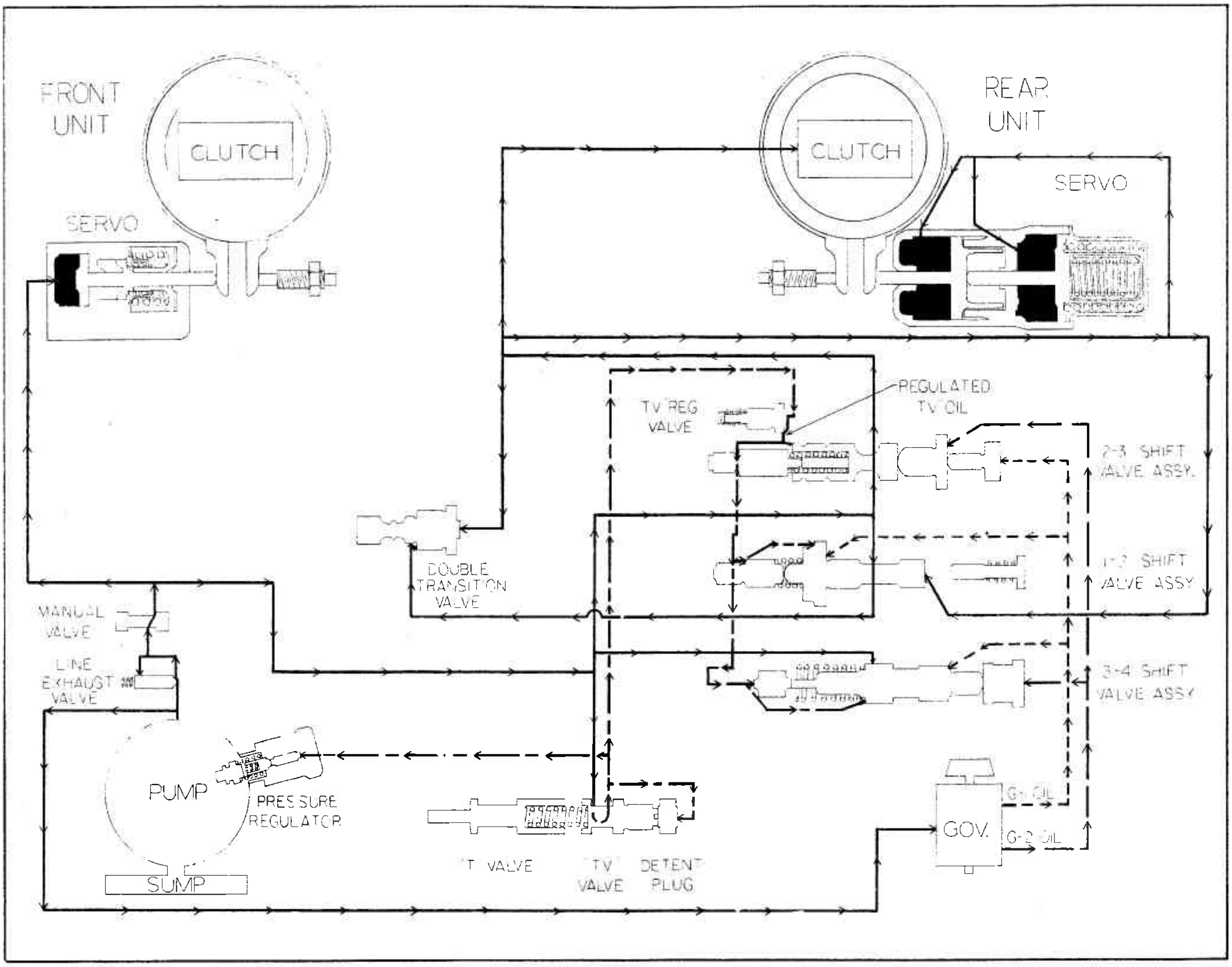

Fig. 23A Hydraulic Action on Part Throttle 4-3 Downshift

PART THROTTLE 4-3 DOWNSHIFT

For improved acceleration from 20-28 MPH it is desirable to downshift from fourth to third gear without going through detent.

TV oil applied to the 3-4 regulator plug and 3-4 shift valve along with the 3-4 shift valve spring is opposed by G-1 and G-2 oil pressures which hold the 3-4 shift valve open in fourth gear.

As the accelerator is pushed down the TV valve is moved and allows additional TV oil pressure to act on the TV regulator valve and 3-4 regulator plug. This additional oil pressure applied to the 3-4 regulator plug and 3-4 shift valve moves the 3-4 shift valve, cutting off main line oil going to the front clutch. As the front clutch is released, the front servo will apply the band providing third gear.

As car speed increases, governor pressure will increase to a point where it will once more move the 3-4 shift valve and open the main line oil passage to the front clutch.

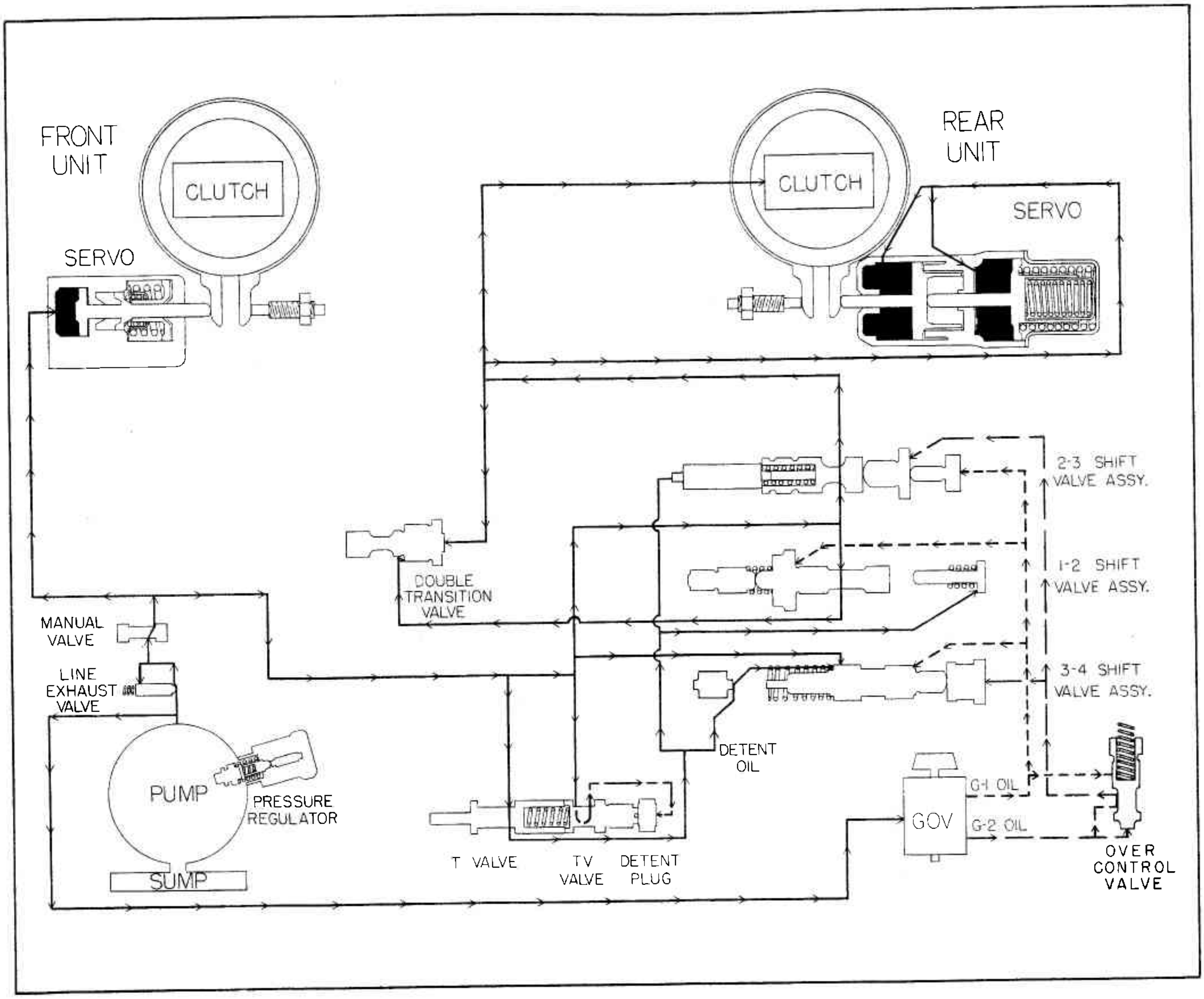

Fig. 24 Hydraulic Action in Forced 4-3 Downshift

FORCED 4-3 DOWNSHIFT

In order to obtain maximum performance from the car it is occasionally desirable, when driving in fourth speed, to downshift to third for rapid acceleration. The forced 4-3 downshift is accomplished by means of the **T** valve. Main line oil pressure is always applied against the land on the **T** valve, but cannot pass during normal operation. However, when the accelerator pedal is pushed until a stop is felt the **T** valve will be pushed against the TV valve, which in turn pushes against the detent plug. If additional pressure is put on the accelerator pedal the detent plug will move back against TV oil pressure to allow main line oil to pass **T** valve.

Main line pressure passing the **T** valve (detent oil) acts on the end of the 4-3 shuttle valve, opening it and directing detent oil behind the 3-4 shift valve.

If the car speed is below approximately 60-65 MPH detent oil pressure at the 3-4 shift valve in addition to regulated TV oil pressure (see page 22) acting on 3-4 regulator plug will close the 3-4 shift valve against governor oil pressure. This will cause the transmission to shift into third speed.

At approximately 70-75 MPH governor oil pressure will overcome the detent oil and regulated TV oil pressure, causing the 3-4 shift valve to open again.

Detent oil is also directed against the 3-2 detent plug but has no effect until car speed is less than 20 MPH. The detent oil directed to 2-1 detent plug has no effect until car speed is less than 10 MPH.

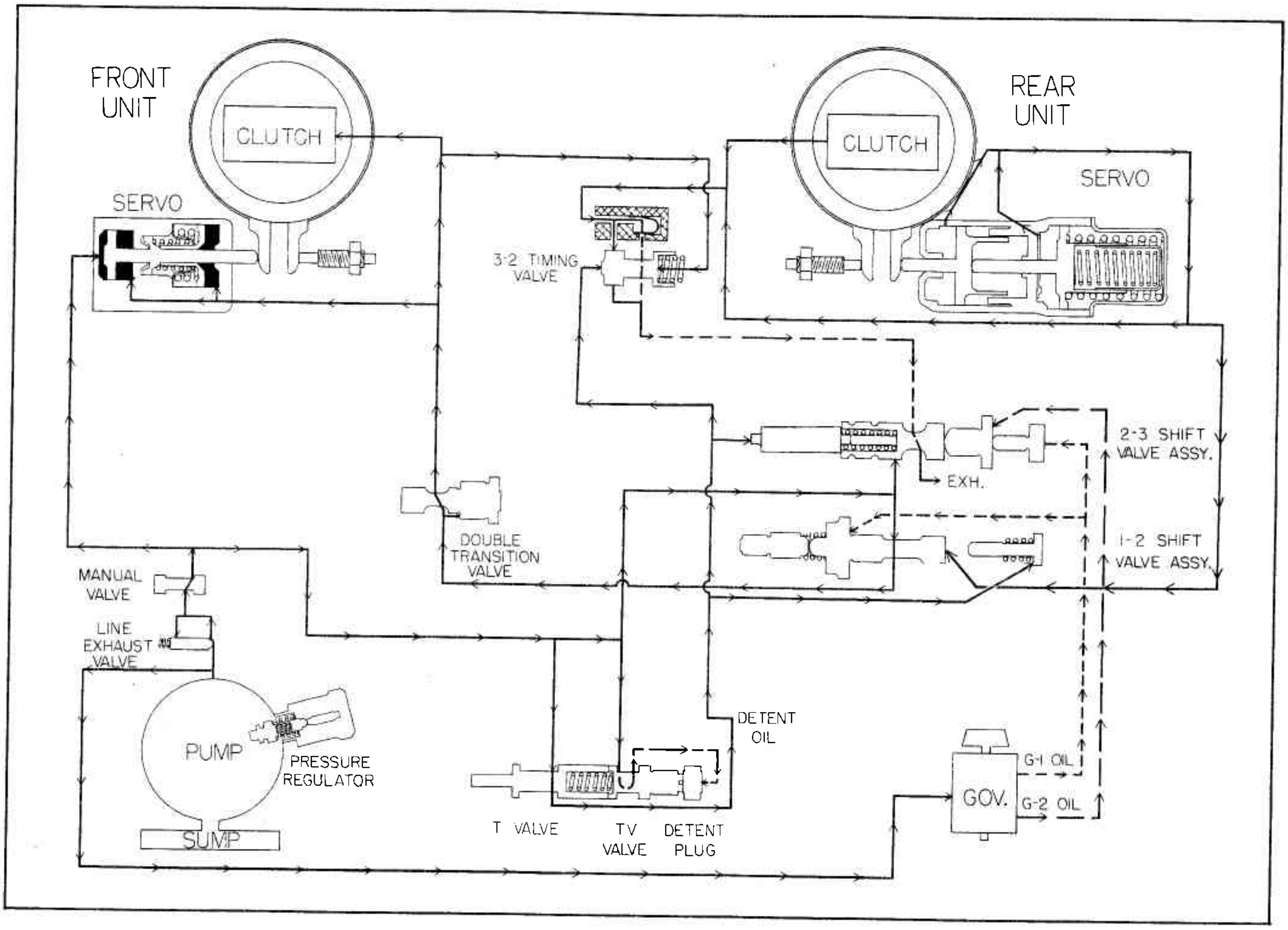

Fig. 25 Hydraulic Action in Forced 3-2 Downshift

FORCED 3-2 DOWNSHIFT

When driving at speeds below 20 MPH it is occasionally desirable to downshift to second to provide rapid acceleration. This feature is also accomplished by means of the T valve. When the accelerator pedal is depressed to the floor, the T valve moves against the detent plug to allow detent oil to be directed to the 3-2 detent plug moving the 2-3 shift valve to the closed position.

In order to provide a smooth 3-2 shift it is necessary to delay the application of the rear band to allow time for the engine to speed up and the front unit to change to direct drive. This is accomplished by means of the 3-2 timing valve and the by-pass valve. Detent oil moves the 3-2 timing valve so that rear clutch and rear servo release oil must pass through orifice in by-pass valve. This delays the application of the rear band until the front servo is released and the front clutch applied. As the front clutch is being applied, front clutch apply oil is also being directed behind the 3-2 timing valve so that the instant the clutch applies the 3-2 timing valve will be moved, allowing rear servo release oil and rear clutch apply oil to exhaust rapidly. This times the application of the front clutch with the application of the rear band and gives a smooth 3-2 forced downshift.

During normal operation the 3-2 timing valve is held in the open position by spring force, allowing the rear servo release oil and rear unit clutch apply oil to exhaust rapidly.

In third and fourth gear, rear servo release oil is directed to the 2-1 detent side of the 1-2 shift valve. This action will soften the possible 3-1 shift by holding the 1-2 shift valve open for a longer length of time.

An advantage of the by-pass valve is that it will lift off its seat to allow rapid flow of release oil into rear servo on full throttle 2-3 upshift.

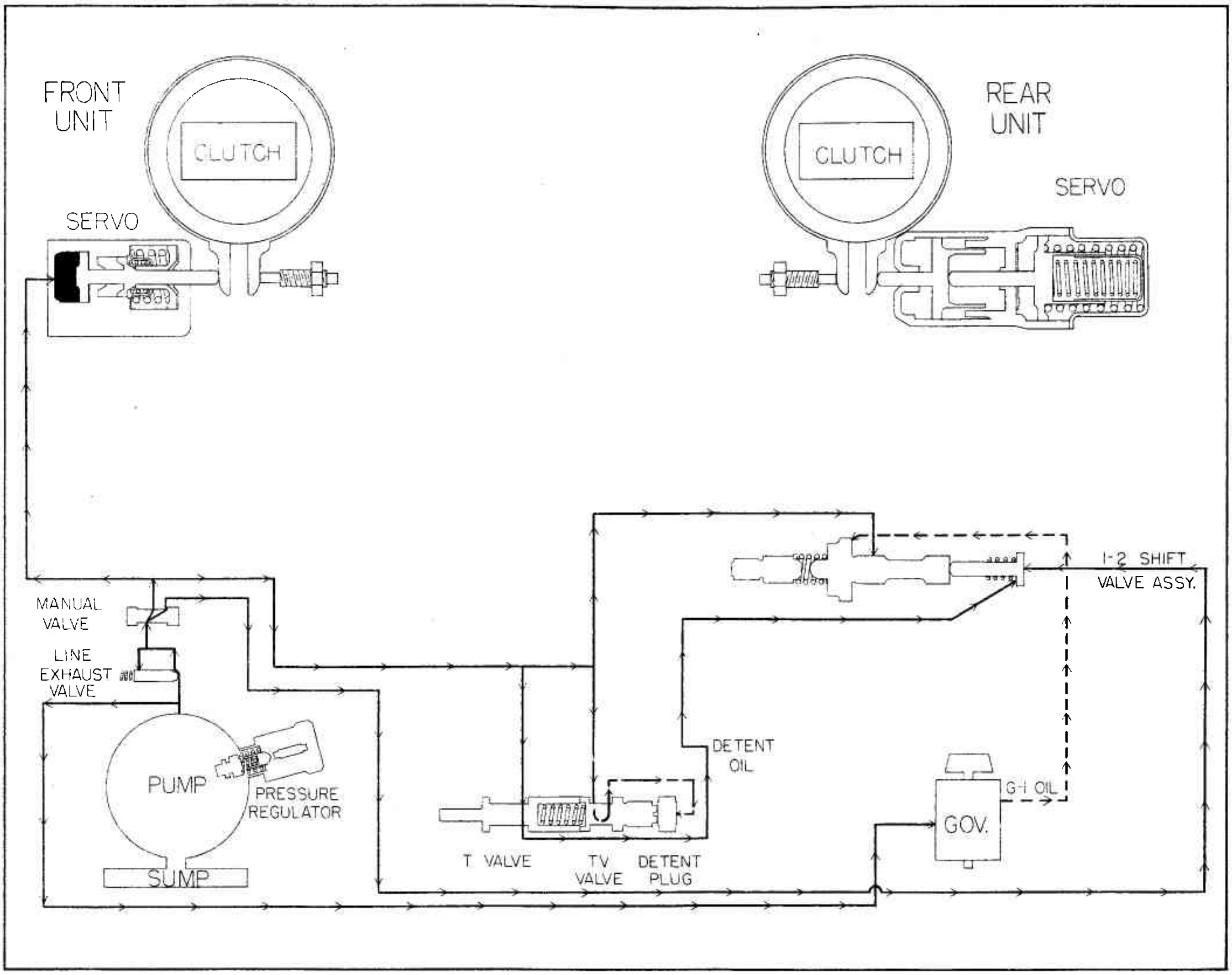

Fig. 26 Hydraulic Action in Forced 2-1 Downshift

FORCED 2-1 DOWNSHIFT

A forced 2-1 downshift can be obtained for greater acceleration in low range or either drive range at speeds below approximately 10 MPH. Governor oil pressure on 1-2 shift valve is low enough at this speed for regulated TV oil pressure (which becomes equal to main line oil pressure with full throttle) to force 1-2 shift valve closed, causing the transmission to shift from 2-1.

Since main line oil which is directed behind the 2-1 detent plug in low range would hold the 1-2 shift valve open, detent oil is directed to the 2-1 detent plug to aid spring force in moving it back. For this reason, it is possible to start out in first speed in low range by pressing the accelerator pedal to the floor.

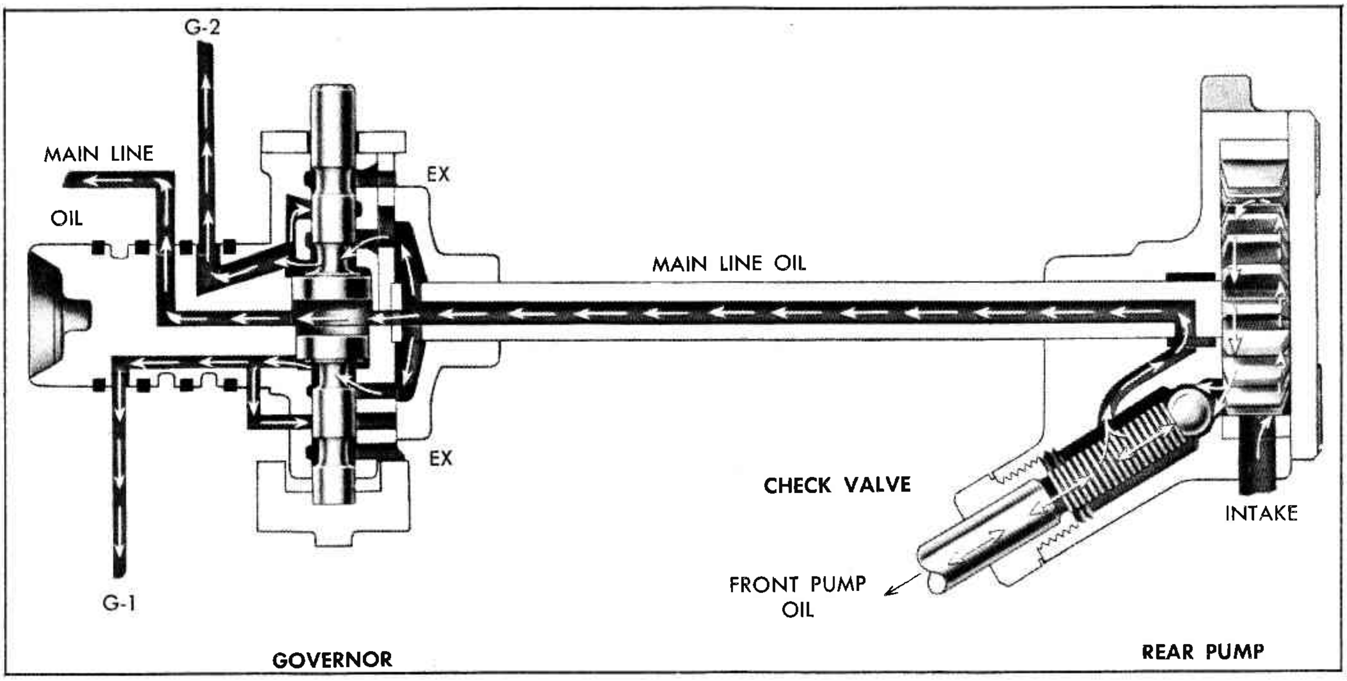

Fig. 27 Rear Pump Operation

OPERATION OF REAR PUMP (FIG. 27)

The rear oil pump is an internal gear type, and is driven by the output shaft. When the car is moving and output shaft is turning, the rear pump builds up pressure and forces the spring loaded check valve off its seat. When the check valve is open, rear pump oil flows with front pump oil and both act as main line oil, which is then delivered at regulated pressure to the governor, parking brake bracket, valve body and balance of transmission.

Main line oil flows to the governor through a hollow pump shaft and then to the parking brake bracket. The rear pump check valve and spring are located in the rear pump body.

OPERATION OF FRONT PUMP

The front oil pump is the variable output vane type pump (Fig. 28) which automatically regulates its output according to the needs of the transmission. It consists of the pump body, cover, slide, rotor, seven vanes, two guide rings and two priming springs.

Output of the pump is controlled by the position of the slide. The slide is held up by the priming spring for maximum output when the pump is started. When the pump is operating the position of the slide is controlled by the pressure regulator valve (Fig. 28). When output pressure is low, the pressure regulator valve is pushed deep into its bore in the pump directing pressure below the slide to hold it up for maximum output. When pressure becomes high the pressure regulator valve is forced outward, directing oil pressure above the slide to push it down and decrease the output (Fig. 29).

When the slide is up it delivers maximum output; when the slide is centered output is zero; when slide is down (Fig. 29) the pump acts as a relief valve for excessive rear pump output. As the slide moves down, it uncovers the torus feed port to supply oil to the fluid coupling and for lubrication.

MAIN LINE PRESSURE REGULATION

Modulated (variable) main line pressure is used to provide smooth shifts under all conditions. During light throttle acceleration main line pressure is low to provide smooth clutch applications. As the throttle is opened, however, throttle pressure is directed behind the TV plug, assisting the pressure regulator spring and increasing main line pressure.

A much higher pressure is provided for reverse operation by directing main line pressure to the reverse booster plug to assist the pressure regulator spring.

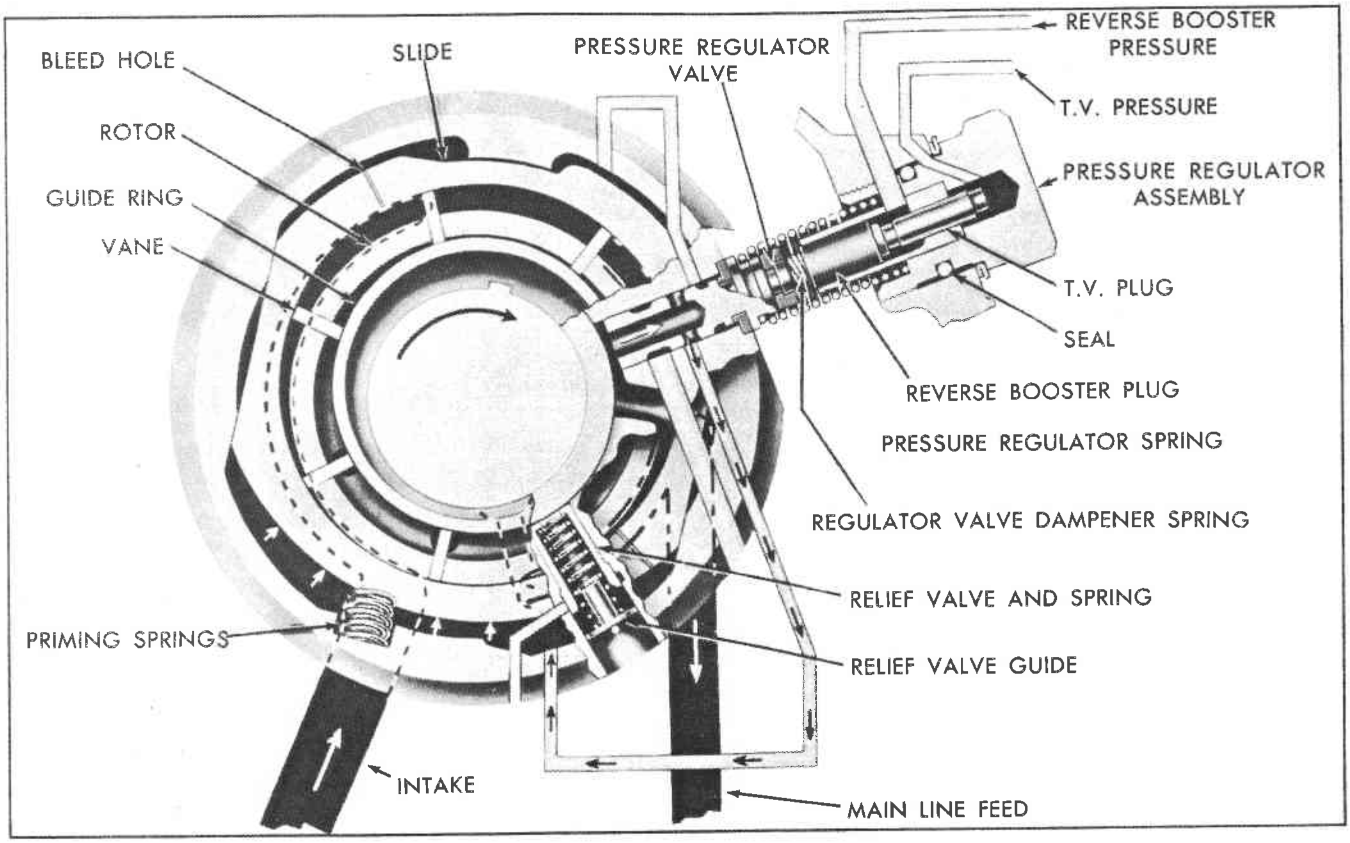

Fig. 28 Slide Up, Pump Delivers Maximum Output

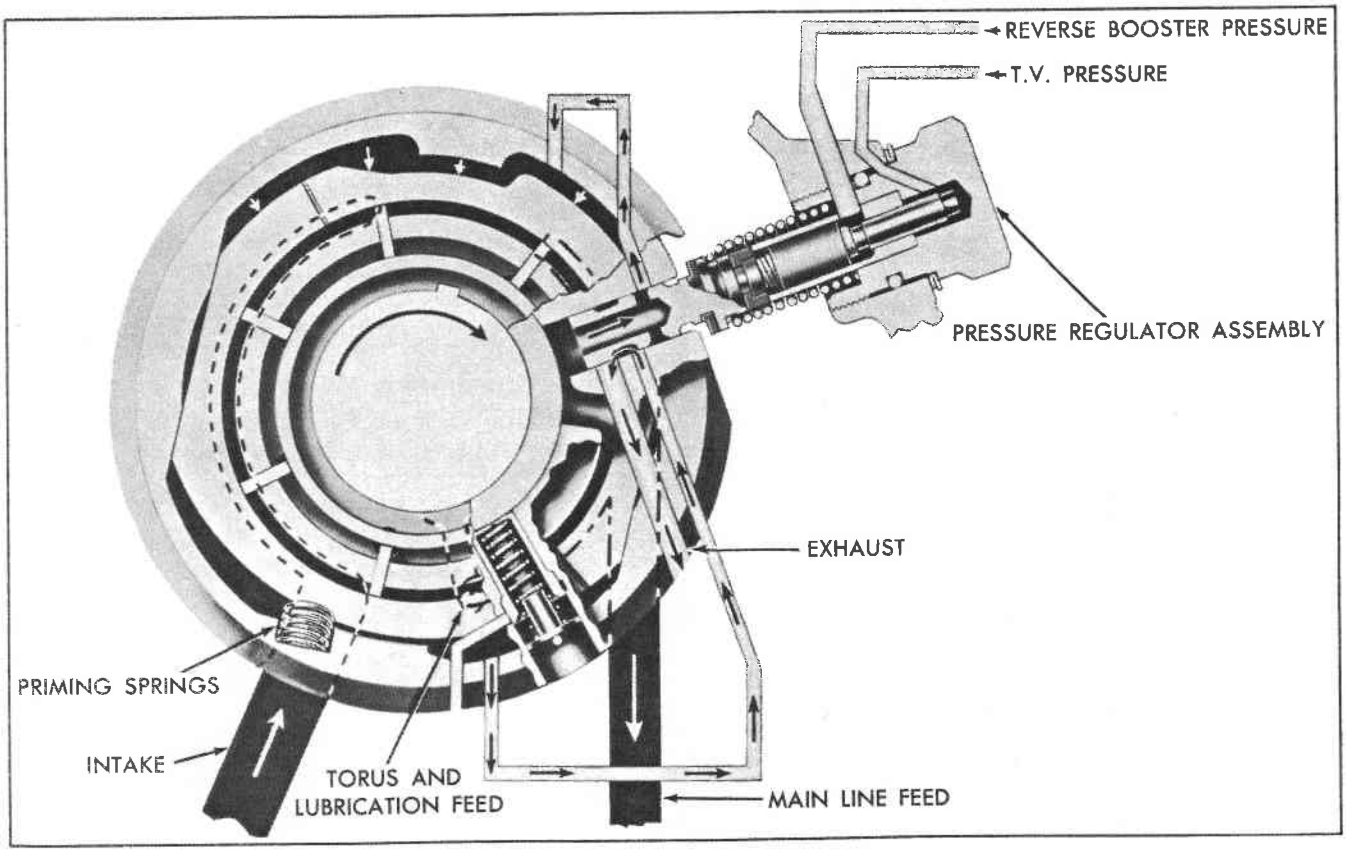

Fig. 29 Slide Down, Pump Output Reduced

OPERATION OF PARKING BLOCKER PISTON AND REVERSE BLOCKER PISTON

REVERSE BLOCKER PISTON

While the car is moving forward at speeds above 8-10 miles per hour, governor pressure is directed behind the reverse blocker piston (Fig. 30). This prohibits the shift lever from being moved to the reverse position. When the car has been slowed to a speed below 8-10 miles per hour the blocker piston return spring overcomes governor oil pressure allowing the shift lever to be moved easily into reverse. Manual valve then directs oil to release the rear band, apply the front servo, and apply the reverse cone clutch.

PARKING BLOCKER PISTON

As the detent lever on the valve body moves into the reverse position, it engages the parking brake lever (Fig. 30). This lever sets the parking brake lever spring in tension against the parking brake pawl crank.

As long as the engine is running or the vehicle is rolling forward at a speed of approximately 4 MPH or more, the parking blocker piston (actuated by line pressure) will prevent the parking pawl from engaging the reverse internal gear.

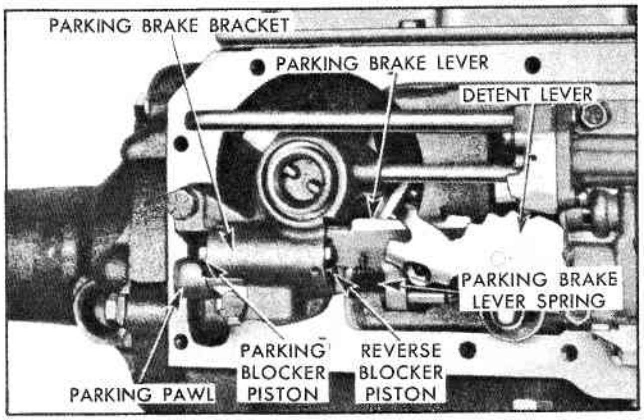

Fig. 30 Parking Brake Bracket Assembly (Blocker Pistons in Lockout Position)

The parking pawl crank is energized by a torsion spring at all times when shift lever is in reverse. When the engine is turned off and the vehicle stops rolling, oil pressure back of the parking blocker piston is reduced, and eventually is overcome by blocker piston release spring. Parking pawl will then complete engagement with teeth on reverse internal gear.

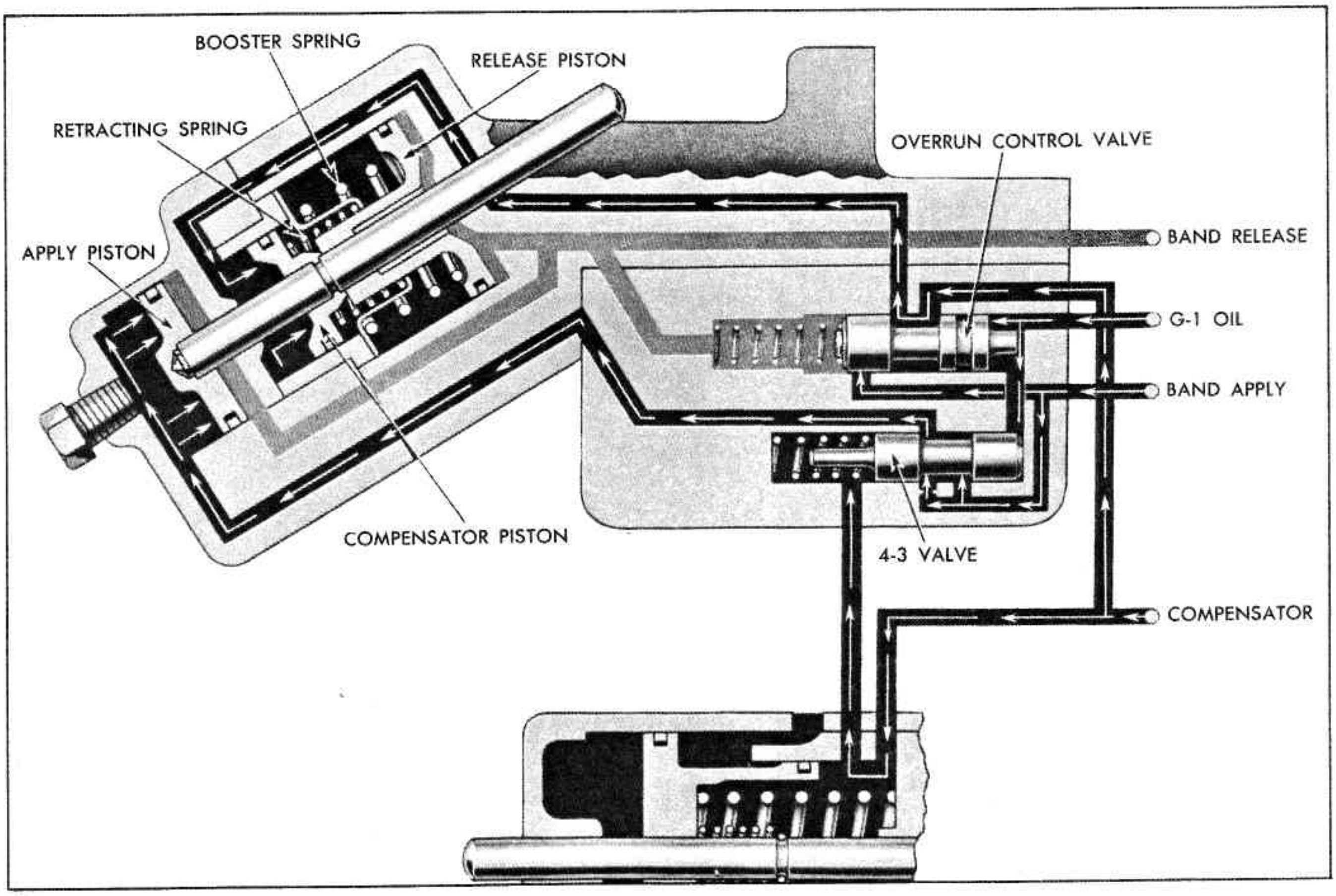

Fig. 31 Front Servo Applied—First Gear

OPERATION OF FRONT SERVO

OPERATION OF FRONT SERVO APPLIED

4-3 Downshift Valve

The 4-3 downshift valve provides a smooth forced downshift from fourth speed to third.

It is held in the open position in first gear (Fig. 31), second gear (Fig. 32) and during the 2-3 shift by spring pressure and compensator pressure; and allows an unrestricted flow of front band apply oil to act on the front servo apply piston.

In third and fourth gear the 4-3 downshift valve is closed by G-1 oil pressure overcoming spring pressure. Compensator pressure is exhausted when rear servo is released.

On a 4-3 downshift (Fig. 33) front band apply oil flows through an orifice which slows down front band apply. This allows an increase in engine speed before the front band applies, thus providing a smooth 4-3 downshift.

Overrun Control Valve

The overrun control valve is used to direct main line pressure to the compensator piston when compensator pressure is low and speed is above 20 MPH. This prevents the front band from slipping when descending grades in 3rd gear using the engine as a brake.

As shown in Fig. 31, with car speed below approximately 20 MPH the overrun control valve spring force is greater than the force exerted by G-1 oil and holds valve in the position where compensator oil is directed to compensator piston. This means that at speeds below 20 MPH the pressure applied to compensator piston varies to suit engine output and main line pressure is directed only to the apply piston.

When the car speed exceeds approximately 20 MPH G-1 oil pressure overcomes the spring force and moves the overrun control valve. This shuts off compensator oil and directs front band apply oil to the compensator piston as shown in Fig. 33. Thus, at speeds of 20 MPH and greater main line oil is directed to both the apply piston and the compensator piston.

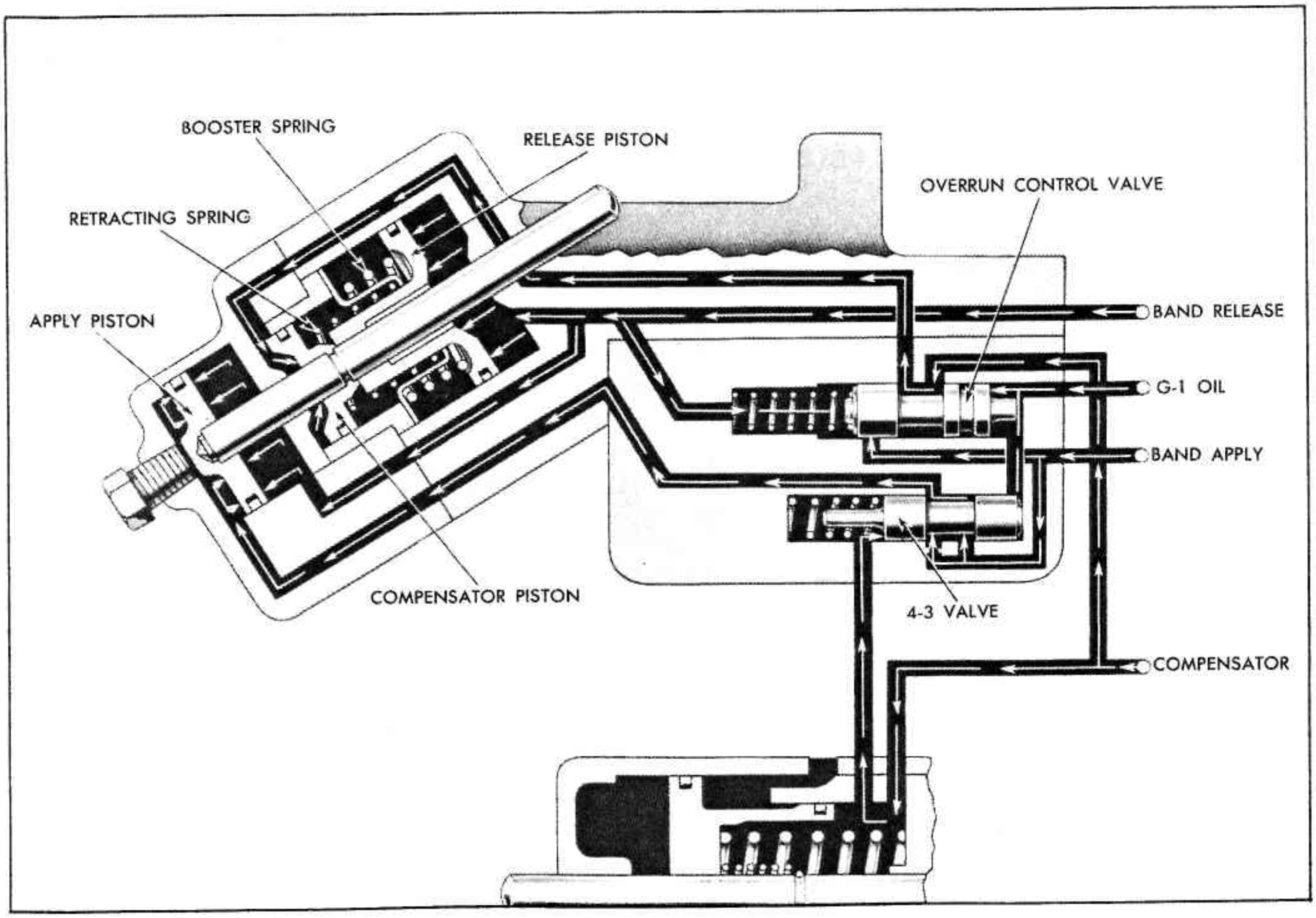

Fig. 32 Front Servo Released—Second Gear

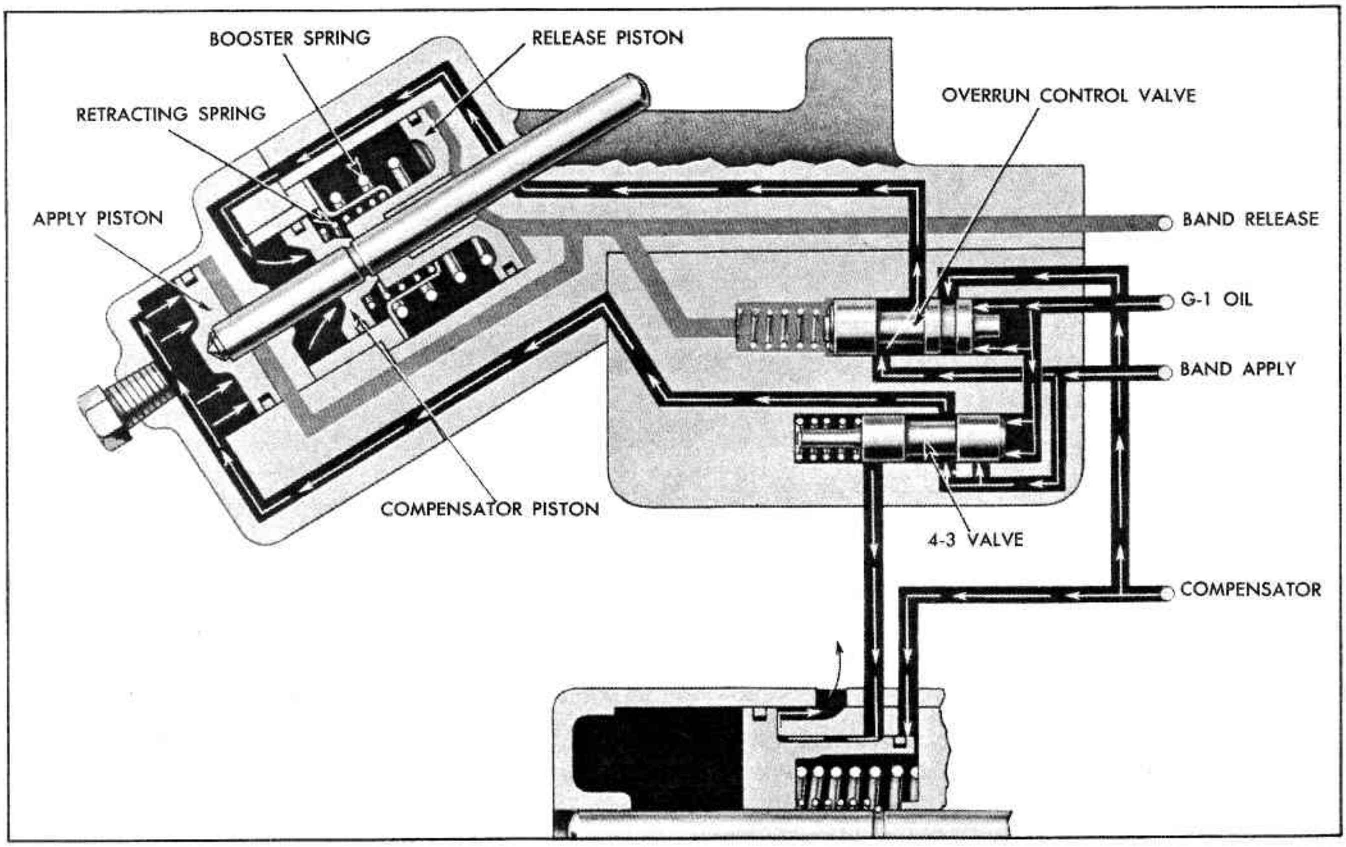

Fig. 33 Front Servo Applied—4-3 Downshift

OPERATION OF FRONT SERVO RELEASED

Release oil pressure directed to the front servo must overcome apply pressure in order to release the band (Fig. 32). To make this possible, release oil is directed to the large release piston and also to the back of the apply piston. In addition, release oil is directed behind the overrun control valve to aid the spring in moving the valve to the position where compensator pressure is directed to the compensator piston rather than main line pressure.

Release pressure against the two large piston areas in addition to retracting spring force then overcomes apply pressure, booster spring force, and compensator pressure to release the front servo.

OPERATION OF MAIN LINE EXHAUST VALVE

The main line exhaust valve is located in the front servo. The purpose of this valve is to exhaust main line pressure very rapidly when the car is parked and the engine is shut off, permitting the parking pawl to engage immediately.

When either pump is operating, pressure behind the main line exhaust valve moves the valve against spring pressure closing off the exhaust port (Fig. 34). When the engine is turned off and the car stops moving (both front and rear pumps stopped), the release spring opens the valve and main line pressure exhausts rapidly allowing the parking blocker piston to release the parking pawl so it can engage immediately.

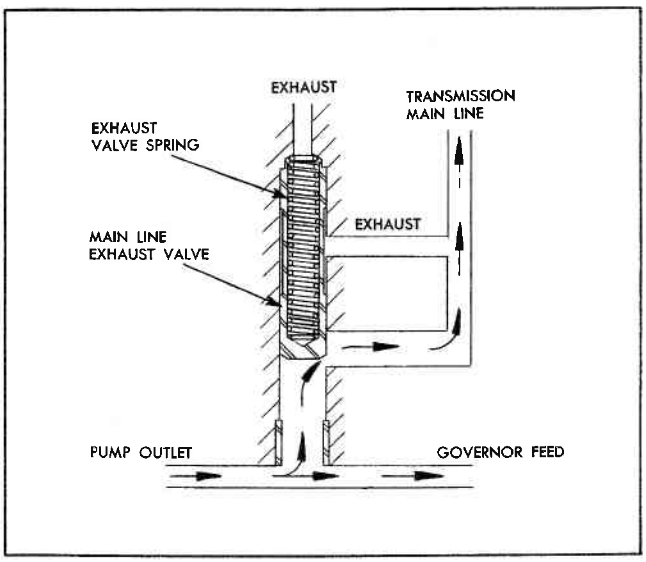

Fig. 34 Schematic View of Main Line Exhaust Valve

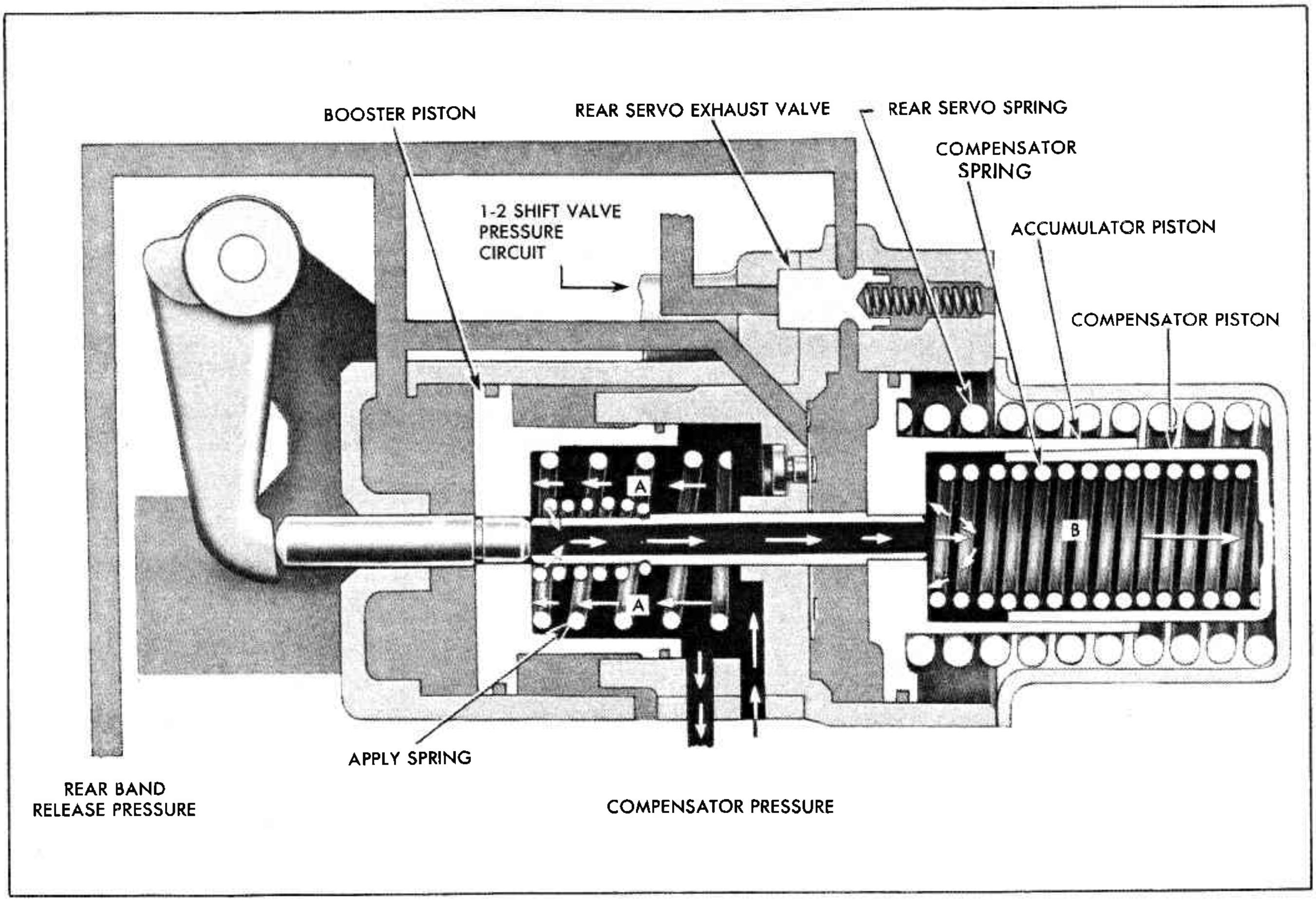

Fig. 35 Rear Servo Applied

OPERATION OF REAR SERVO

APPLY

The rear servo is applied by the servo springs which operate on the accumulator piston, the stem of which contacts the booster piston applying the band (Fig. 35).

Compensator Pressure

Compensator pressure is applied at points A and B to assist the servo springs and to prevent the band slipping under rapid acceleration. Compensator pressure is always present when there is any carburetor throttle opening and increases with carburetor throttle opening (Fig. 35). It is also directed to the Front Servo to aid in positioning the 4-3 valve.

RELEASE

Regulated main line pressure is applied at points C and D to release the band. The force applied at these two areas is greater than the force of the servo springs and the compensator pressure and the servo pistons are moved to the released position (Fig. 36). Compensator oil from the 4-3 downshift valve is then exhausted through the rear servo.

ACCUMULATOR CHECK VALVE AND PLUNGER

This accumulator check valve controls the passage through which oil flows to the face of the accumulator piston at D. The oil going through this passage lifts the check valve off its seat and allows the oil to flow through freely to release the band.

There are two different ways in which this valve operates when the servo is being applied, namely closed and open carburetor throttle.

1. On a closed carburetor throttle downshift when the main line pressure applied at point D is released the check valve then returns to its seat causing the oil under the accumulator piston to pass through the small hole in the check valve and in this way delays application of the band (Fig. 35).

2. On an open carburetor throttle downshift, compensator pressure is effective at points A and B and also on the end of the check valve plunger which is connected to the accumulator check valve. When the pressure applied at point D is released the compensator pressure applied on the check valve plunger holds the check valve off its seat and the oil under the accumulator piston is allowed to exhaust freely for a rapid application of the band (Fig. 36).

REAR SERVO EXHAUST VALVE

The purpose of the rear servo exhaust valve is to provide a rapid rear band application when shifting from Neutral or Reverse to Drive.

The exhaust valve is held open by spring pressure so that when shifting into Drive, release oil from the rear servo can be rapidly exhausted (Fig. 35). When the 1-2 shift valve opens to shift the transmission into second speed, oil from the 1-2 shift valve closes the rear servo exhaust valve to make it inoperative in second, third and fourth speeds (Fig. 36).

OPERATION OF REVERSE CONE CLUTCH

When the selector lever is moved to the reverse position, oil is directed from the valve body through the reverse clutch oil pipe, through the case, and then into the reverse assembly. Oil is retained in the reverse assembly with two seals; an inner seal on the rear bearing retainer and an outer seal on the cone clutch piston (Fig. 37). While under pressure, oil pushes the cone clutch piston forward engaging the internal surface of the reverse cone. This action forces the entire reverse cone forward causing the outside surface of the reverse cone to contact the stationary cone, thereby holding the reverse internal gear by friction.

When the selector lever is moved to any other position, the cone clutch piston releases. When pressure is cut off, the six cone clutch piston release springs disengage the piston. When the reverse clutch piston is applied, there is some float in the reverse internal gear. To get release, the reverse internal gear must be centralized. This is obtained through the action of the reverse clutch release spring installed on inside of the reverse internal gear.

Teeth cut on the outside of internal gear are used only for parking.

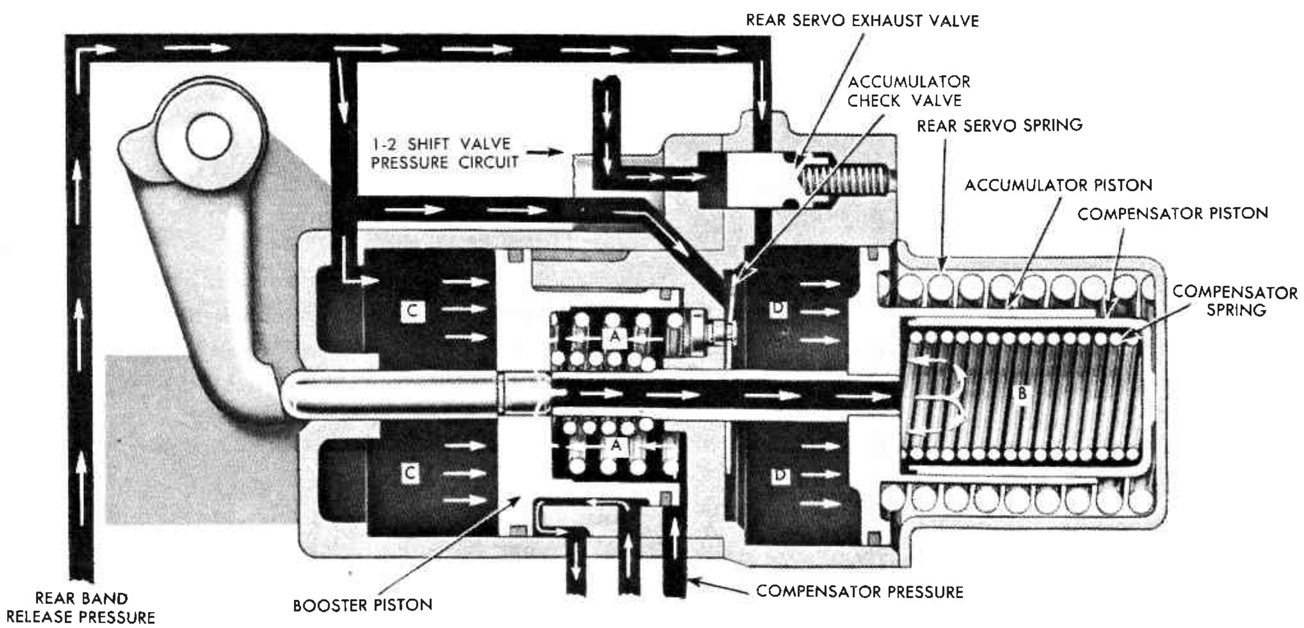

Fig. 36 Rear Servo Released

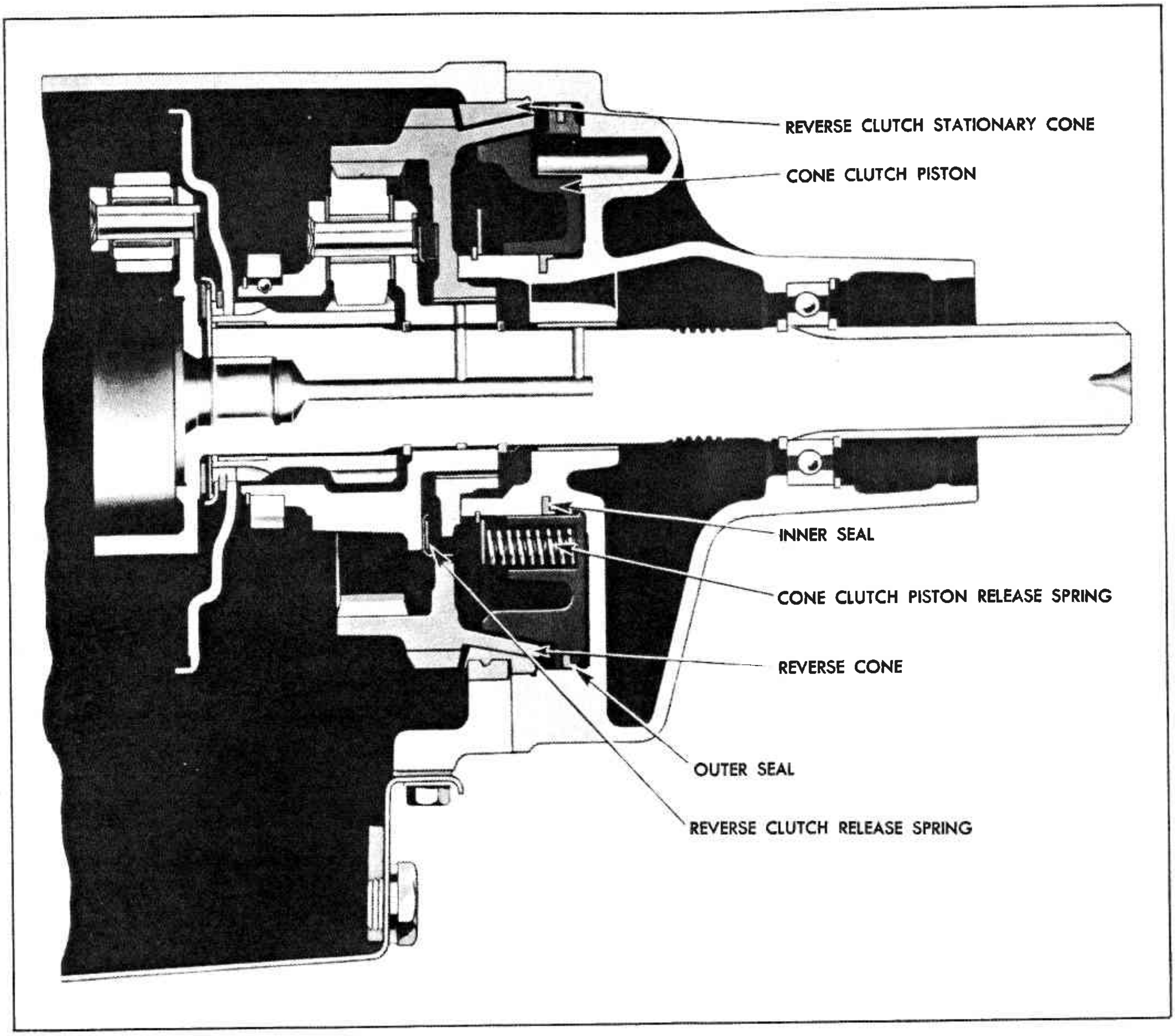

Fig. 37 Reverse Assembly Construction