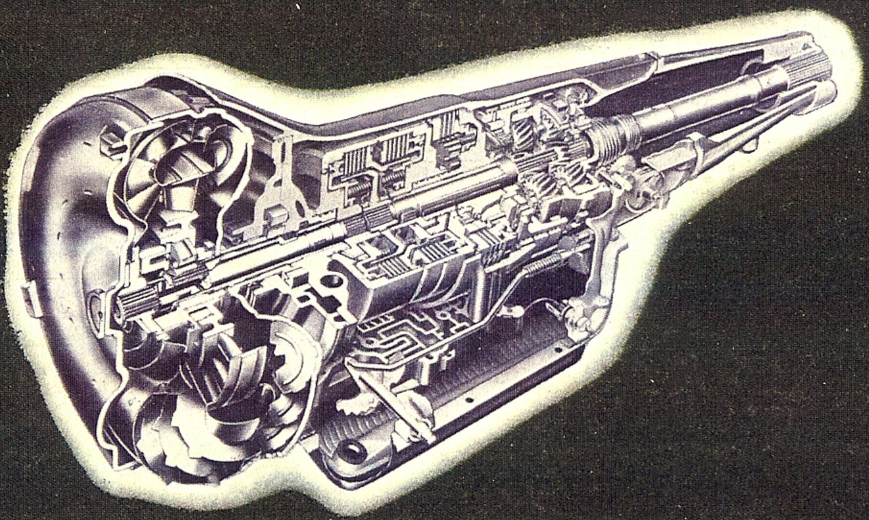
# Hydra-matic

# 400



## *Principles of Operation*

SECOND EDITION

# HYDRA-MATIC 400

TURBO HYDRA-MATIC

# PRINCIPLES OF OPERATION

## SECOND EDITION

## FOREWORD

This booklet gives the reader a comprehensive understanding of the principles of operation of the Model 400 Hydra-matic transmission. The mechanical function or power flow, as well as the hydraulic operation, are described in detail.

There are several variations of the Model 400 transmission as used by the car manufacturers. This second edition describes the general features of the transmission and converter of the fixed stator design as used by all manufacturers.

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LITHO IN U.S.A.

## INDEX

Hydra-matic

Division of General Motors,
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Office of the General Manager

## A MESSAGE FROM HYDRA-MATIC'S GENERAL MANAGER

This booklet has been prepared to explain the operating principles of the General Motors Model 400 Turbo Hydra-matic transmission. It is intended to answer the question, "How does it work?"

For more than 30 years, Hydra-matic, the pioneer, has been producing the world's finest automatic transmissions. The model 400 Turbo Hydra-matic represents the newest and finest of the famous Hydra-matic family of automatic transmissions. This record of product leadership and excellence, however, could not be achieved without the "Hydra-matic Team"---our employes, suppliers, those who service our products, and the community where we live. We are very proud of this team for it has helped us manufacture, sell and service a quality product.

We pledge ourselves to continue to supply products of the highest quality and superiority which will fulfill the standards of reliability, safety, performance and styling needs.

Thank you for your interest in our product and I hope that this booklet will answer any questions as to its operation.

Sincerely,

G. W. Griffith

G. W. Griffith

# HYDRA-MATIC 400

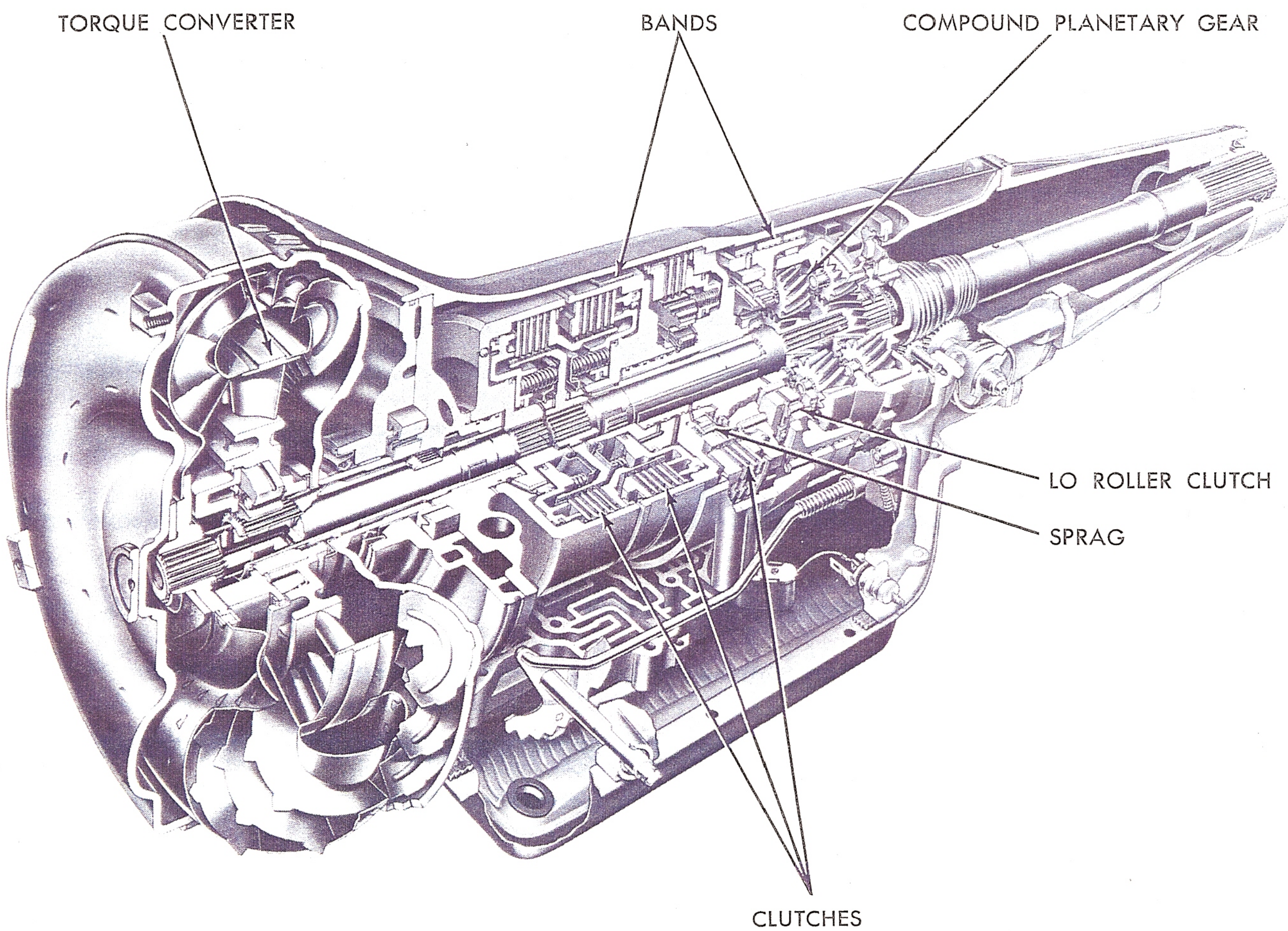



Fig. 1 Cut-Away View Model 400 Hydra-matic

## GENERAL DESCRIPTION

The Model 400 Hydra-matic transmission is a fully automatic unit consisting primarily of a 3-element hydraulic torque converter and a compound planetary gear set. Three multiple-disc clutches, one sprag, one roller clutch, and two bands provide the friction elements required to obtain the desired function of the compound planetary gear set. (Fig. 1)

The torque converter smoothly couples the engine to the planetary gears through oil and hydraulically provides additional torque multiplication when required. The compound planetary gear set gives three forward ratios and one reverse.

The torque converter consists of a driving member, driven member, and a reaction member known respectively as the pump, turbine, and stator. Changing of the gear ratios is fully automatic in relation to vehicle speed and engine torque input. Vehicle speed and engine torque signals are constantly fed to the transmission to provide the proper gear ratio for maximum efficiency and performance at all throttle openings.

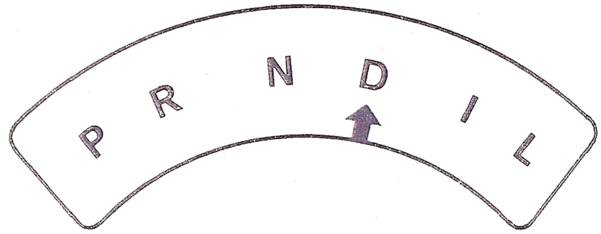



Fig. 2 Quadrant in Drive Position

The quadrant has six positions indicated in the following order: P, R, N, D, I, L. (Fig. 2)

P - Park position enables the transmission output shaft to be locked - thus preventing the vehicle from rolling either forward or backward. Because the output shaft is mechanically locked by a parking pawl anchored in the case, the park position should not be selected until the vehicle has come to a stop. The engine may be started in the park position.

R - Reverse enables the vehicle to be operated in a reverse direction.

N - Neutral position enables the engine to be started and operated without driving the vehicle.

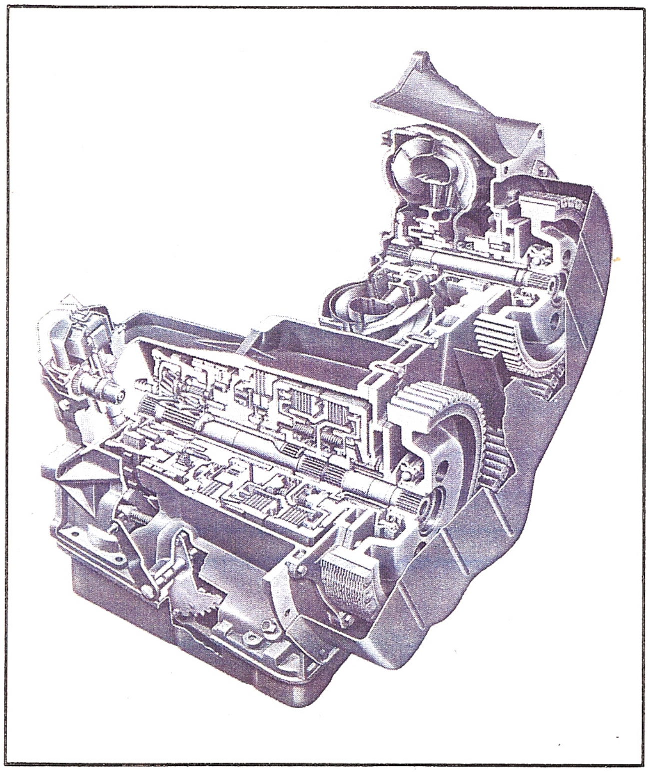


Fig. 2A Cut-Away View Model 425 Hydra-matic

D - Drive range is used for all normal driving conditions and maximum economy. Drive range has three gear ratios, from the starting ratio to direct drive. Downshifts are available for safe passing by depressing the accelerator fully to the floor.

I* - Intermediate range adds new performance for congested traffic or hilly terrain. It has the same starting ratio as Drive range, but prevents the transmission from shifting above second gear to retain second gear for acceleration or engine braking as desired. Intermediate range can be selected at any vehicle speed. The transmission will shift to second gear immediately and remain in second until the vehicle speed or the throttle position are changed to obtain first gear operation in the same manner as in Drive range.

L+ - Lo range can be selected at any vehicle speed. The transmission will shift to second gear immediately and remain in second until vehicle speed is reduced to approximately 40 mph, at which time the transmission will shift to first gear and remain in first gear regardless of speed or throttle position. This is particularly beneficial for maintaining maximum engine braking when continuous first gear operation is desirable.

*Sometimes marked $D_{II}$, S or $L_2$
+Sometimes marked $L_1$

## HYDRA-MATIC 425

In addition to the model 400 transmission Hydra-matic Division produces a model 425 transmission for use in the General Motors front-wheel drive passenger cars. The principles of operation for the model 425 are similar to those described in this booklet for the model 400.

# PRINCIPLES OF OPERATION

The purpose of an automobile transmission is to provide neutral, reverse, and forward driving ranges that increase the torque or twisting force from the engine to the rear wheels as required for greater pulling power and performance.

Basically, an automobile transmission is a form of lever that enables the engine to move heavy loads with less effort. As the heavy load or vehicle begins to move, less leverage or ratio is required to keep it moving.

By providing a suitable number of levers or torque multiplying ratios, improved performance and economy are possible over the entire driving range. Changing the ratio automatically relieves the driver of the responsibility of selecting the best possible ratio for each condition and makes driving safer and easier.

## PLANETARY GEARS

Planetary gears are used in the Hydra-matic 400 transmission as the basic means of multiplying the twisting force or torque from the engine. Planetary gears are so named because of their physical arrangement. They are always in mesh and thus cannot "clash" like other gears that go in and out of mesh. The gears are designed so that several gear teeth are in mesh or in contact at once. This distributes the forces over several teeth for greater strength. Because the shafts generally used with planetary gear trains can be arranged on the same centerline, a very compact unit can be obtained.

A planetary gear train consists of a center or sun gear, an internal gear (so called because of its internally cut teeth), and a planetary carrier assembly which includes and supports the smaller planet gears called pinions. (Fig. 3)

A planetary gear train can be used to increase torque, increase speed, reverse the direction of rotation, or function as a coupling or connector for direct drive. Increasing the twisting force or torque is generally known as operating in reduction, (Fig. 4) because there is always a decrease in the speed of the output member which is proportional to the increase in the output torque.

Stated in another way - with a constant input speed, the output torque increases as the output speed decreases.

Reduction can be obtained in several ways:

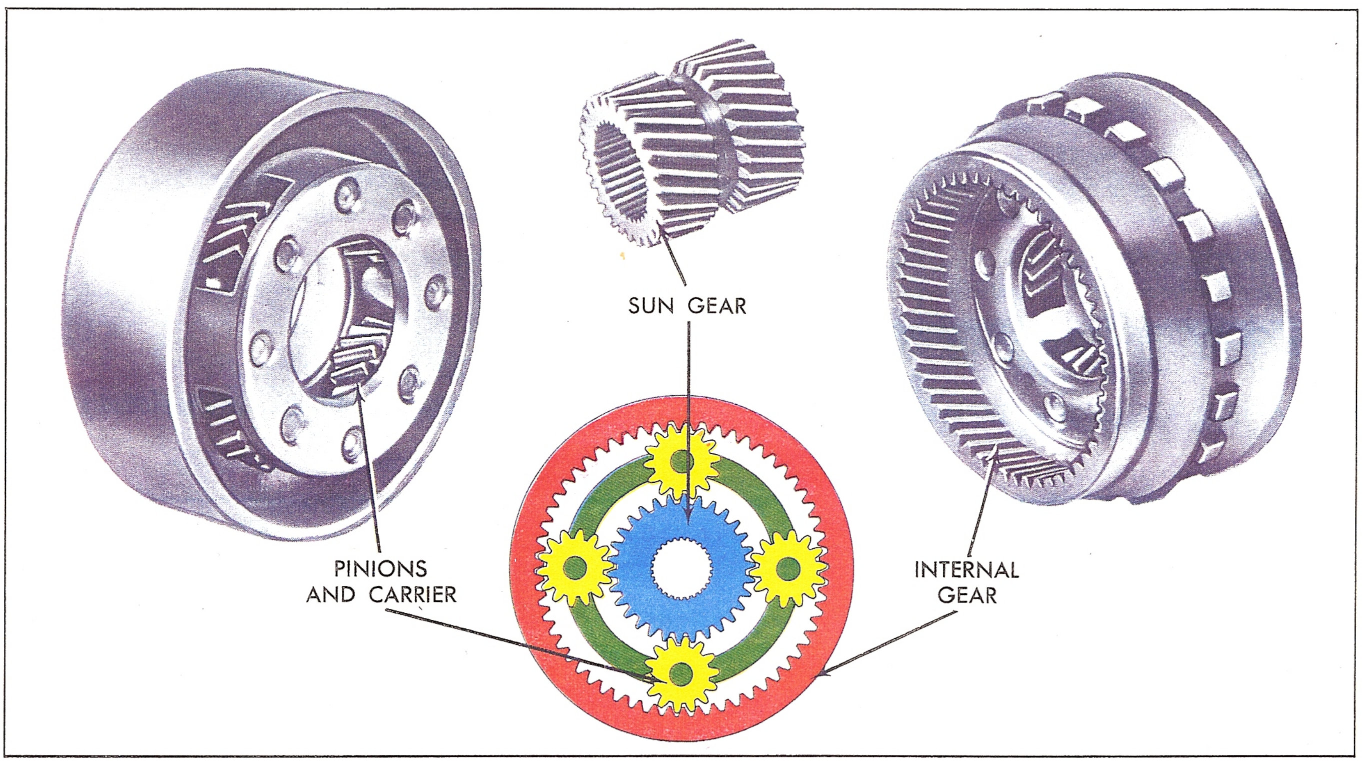



Fig. 3 Planetary Gear Set

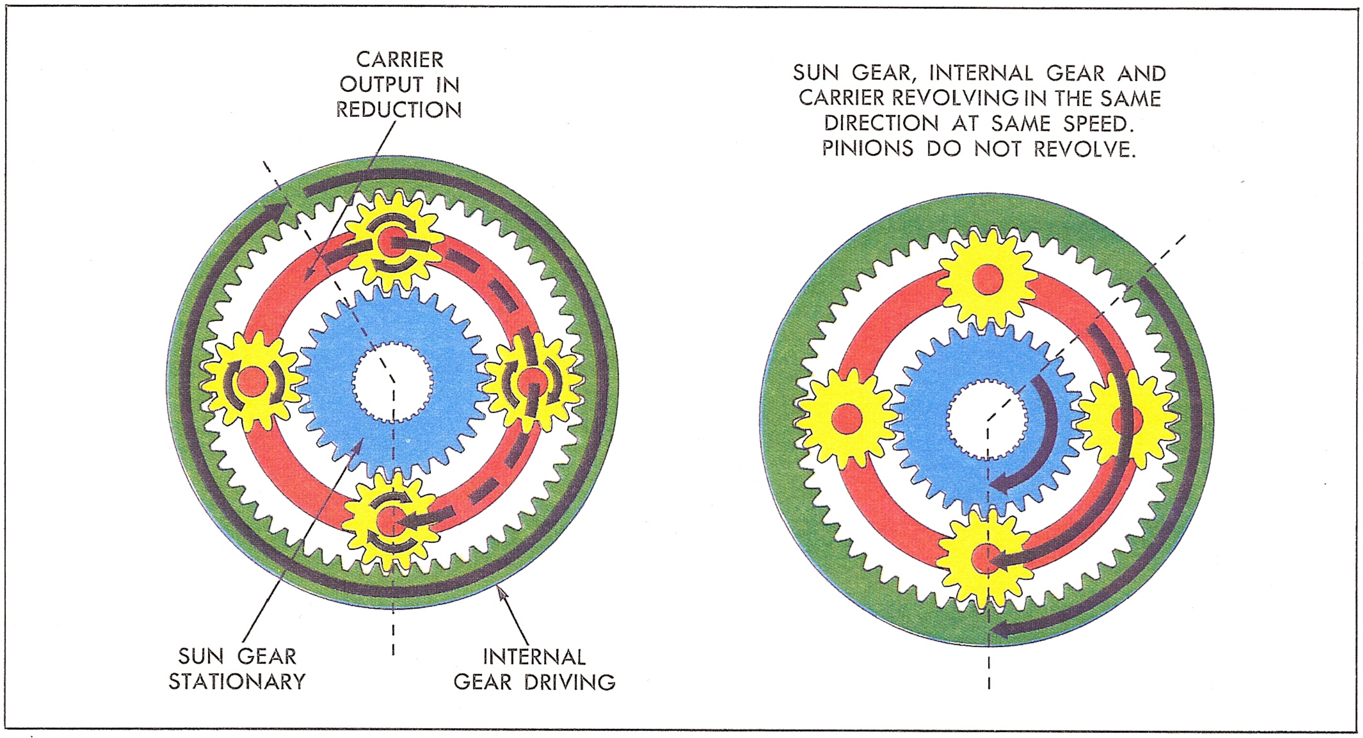



Fig. 4 Simple Reduction-Direct Drive

## SIMPLE REDUCTION

When the sun gear is held stationary and power is applied to the internal gear in a clockwise direction, the planetary pinions rotate in a clockwise direction and "walk" around the stationary sun gear, thus rotating the carrier assembly clockwise in reduction. (Fig. 4)

## DIRECT DRIVE

Direct drive is obtained when any two members of the planetary gear train rotate in the same direction at the same speed. This forces the third member to turn at the same speed. In this condition, the pinions do not rotate on their pins but act as wedges to lock the entire unit together as one rotating part. (Fig. 4)

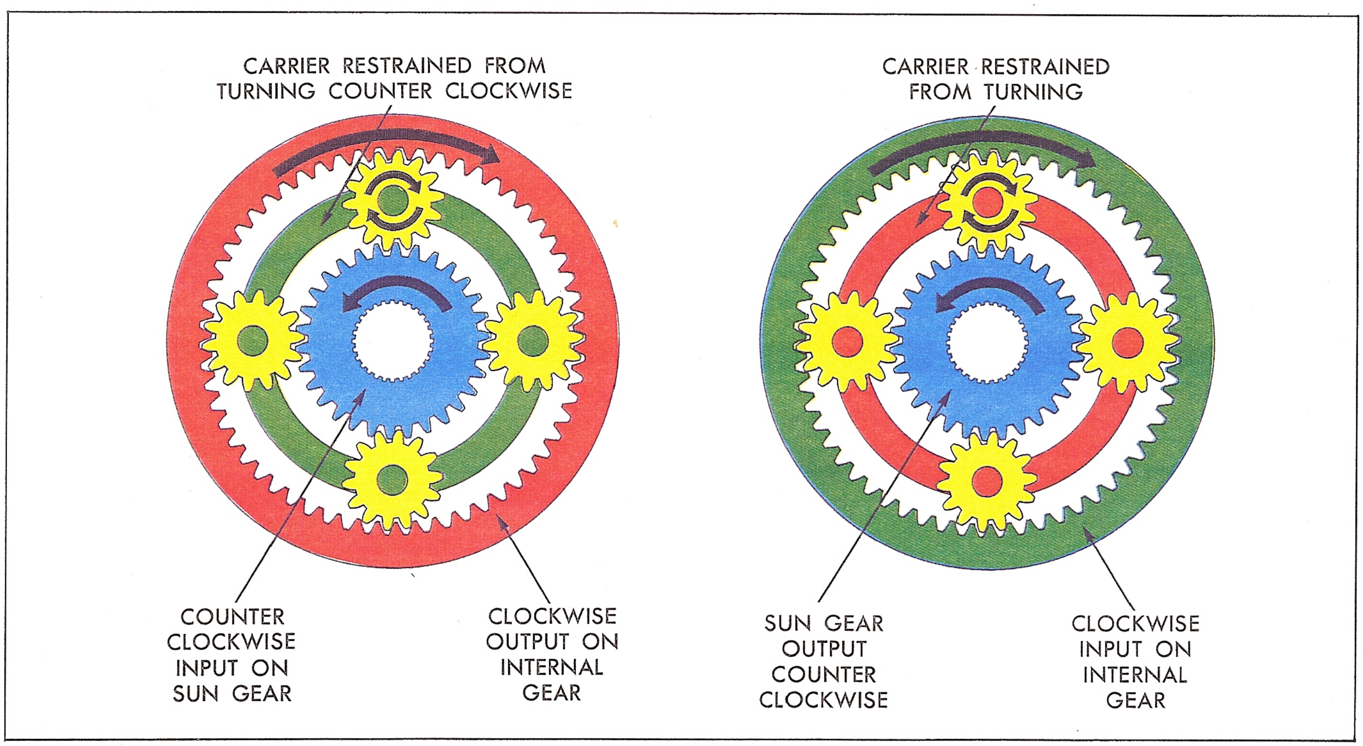



Fig. 5 Reversal of Direction

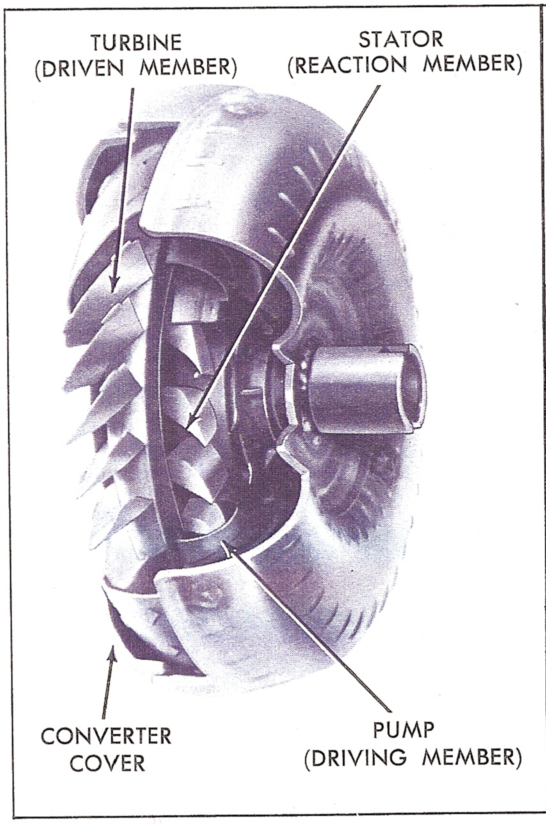



Fig. 6 Torque Converter Assembly

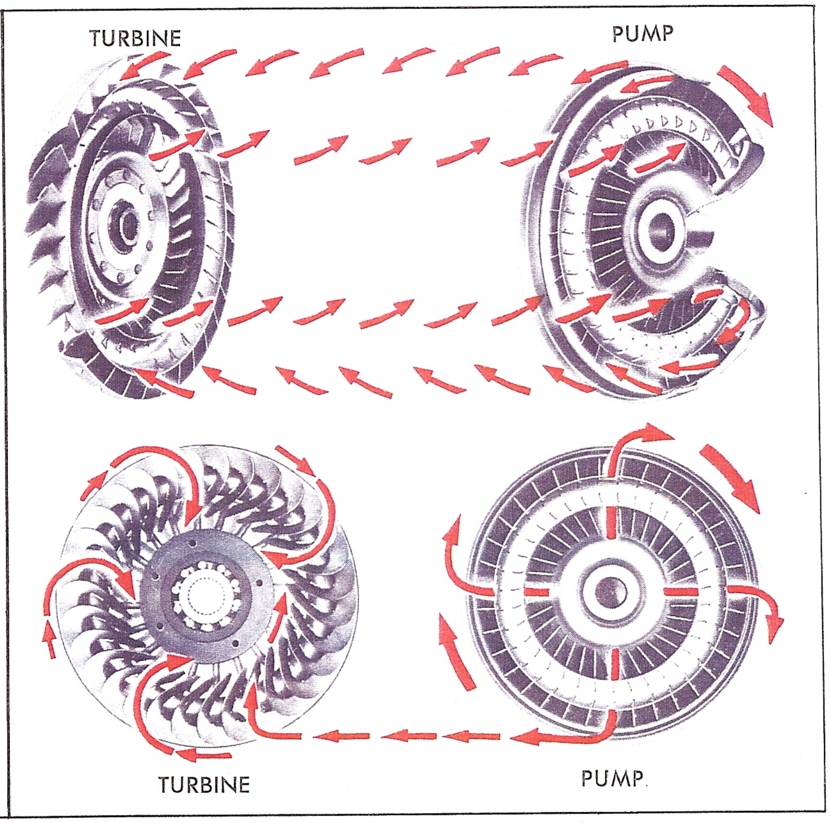



Fig. 7 Oil Flow without Stator

## REVERSAL OF DIRECTION

A reversal of direction is obtained whenever the carrier is restrained from spinning free and power is applied to either the sun gear or internal gear. This causes the planet pinions to act as idlers, thus driving the output member in the opposite direction. (Fig. 5)

In both cases the output member is turning in a direction opposite the input member.

## TORQUE CONVERTER OPERATION

The torque converter serves two primary functions. First, it acts as a fluid coupling to smoothly connect engine power through oil to the transmission gear train. Second, it multiplies the torque or twisting effort from the engine when additional performance is desired.

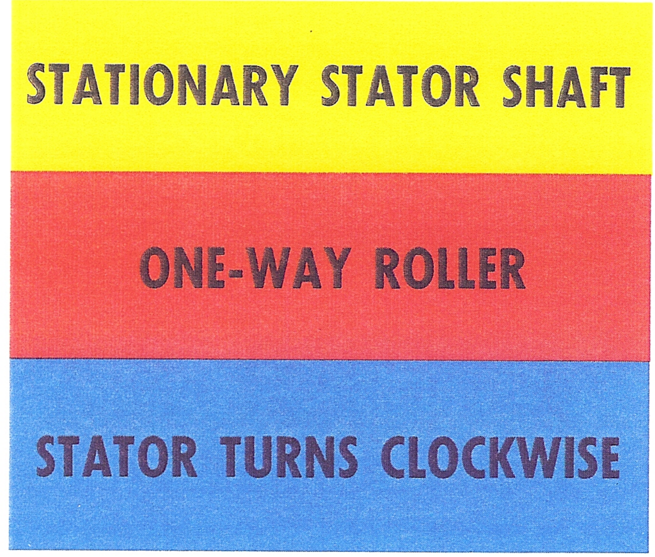
The torque converter consists of three basic elements: the pump (driving member), the turbine (driven or output member), and the stator (reaction member). (Fig. 6) The converter cover is welded to the pump to seal all three members in an oil filled housing. The converter cover is bolted to the engine flex-plate which is bolted directly to the engine crankshaft. The converter pump is therefore mechanically connected to the engine and turns at engine speed whenever the engine is operating.

When the engine is running and the converter pump is spinning, it acts as a centrifugal pump, picking up oil at its center and discharging this oil at its rim between the blades. (Fig. 7) The shape of the converter pump shells and blades causes this oil to leave the pump spinning in a clockwise direction toward the blades of the turbine. As the oil strikes the turbine blades, it imparts a force to the turbine causing it to turn. When the engine is idling and the converter pump is not spinning fast, the force of the oil leaving the pump is not great enough to turn the turbine with any efficiency. This allows the vehicle to stand in gear with the engine idling. As the throttle is opened and the pump speed increases, the force of the oil increases and engine power is more efficiently transmitted to the turbine member and the gear train.

After the oil has imparted its force to the turbine, the oil follows the contour of the turbine shell and blades so that it leaves the center section of the turbine spinning counter-clockwise.

Because the turbine member has absorbed the force required to reverse the direction of the clockwise spinning oil, it now has greater force or torque than is being delivered by the engine. The process of multiplying engine torque through the converter has begun. If the counter-clockwise spinning oil was allowed to continue to the inner section of the pump member, the oil would strike the blades of the pump in a direction that would hinder its rotation, thus canceling out any gains in torque that have been obtained. To prevent this from happening, a stator assembly is added.

The stator is located between the pump and turbine and is mounted on a one-way or roller clutch which allows it to rotate clockwise but not counter-clockwise.




The purpose of the stator is to redirect the oil returning from the turbine and change its direction of rotation back to that of the pump member. (Fig. 8) The energy of the oil is then used to assist the engine in turning the pump. This increases the force of the oil driving the turbine and, as a result, multiplies the torque or twisting force.

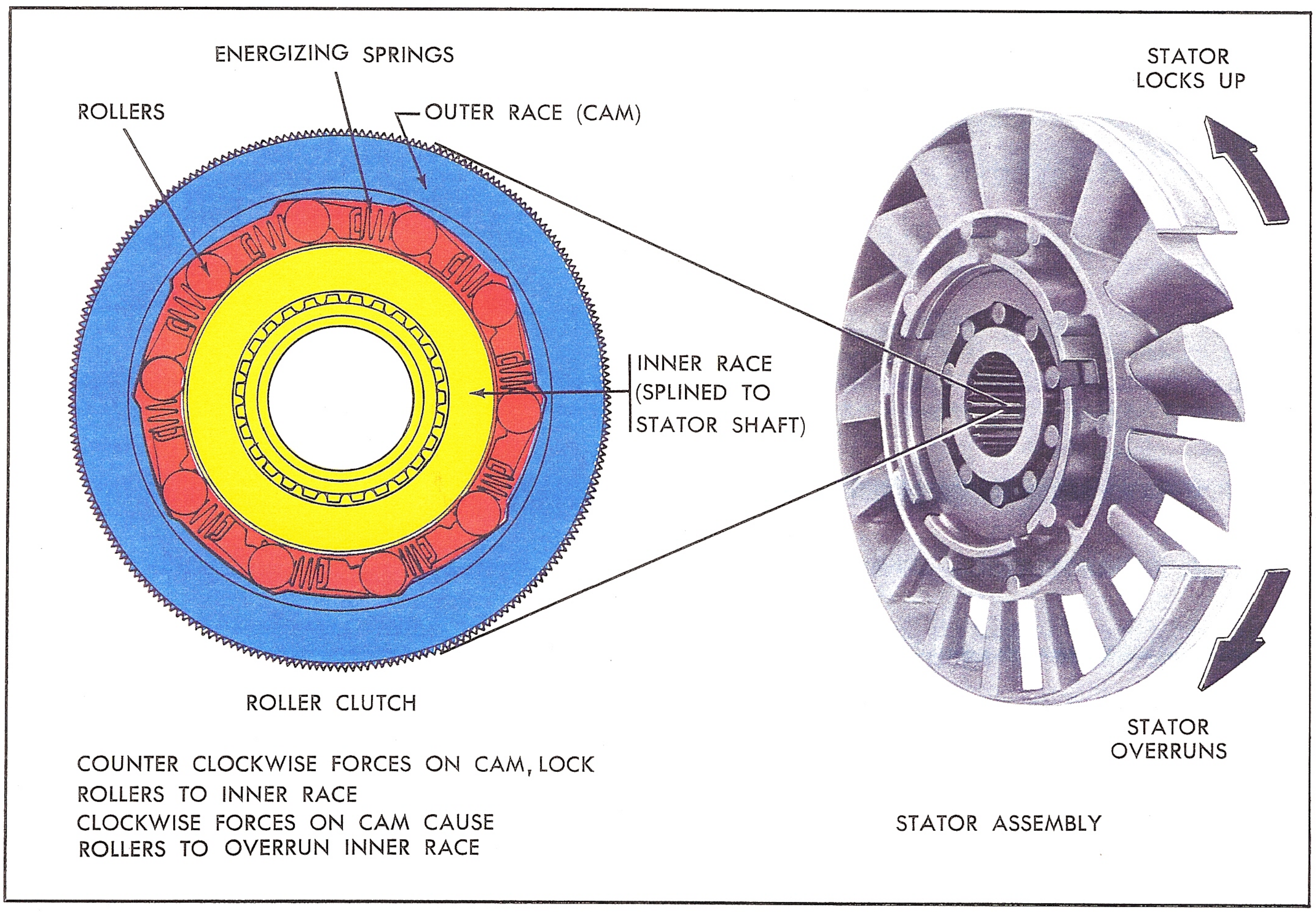



Fig. 8 Roller Clutch and Stator Assembly

The force of the oil flowing from the turbine to the blades of the stator tends to rotate the stator counter-clockwise, but the roller clutch prevents it from turning. (Fig. 9)

With the engine operating at full throttle, transmission in gear, and the vehicle standing still, the converter is capable of multiplying engine torque by approximately 2:1.

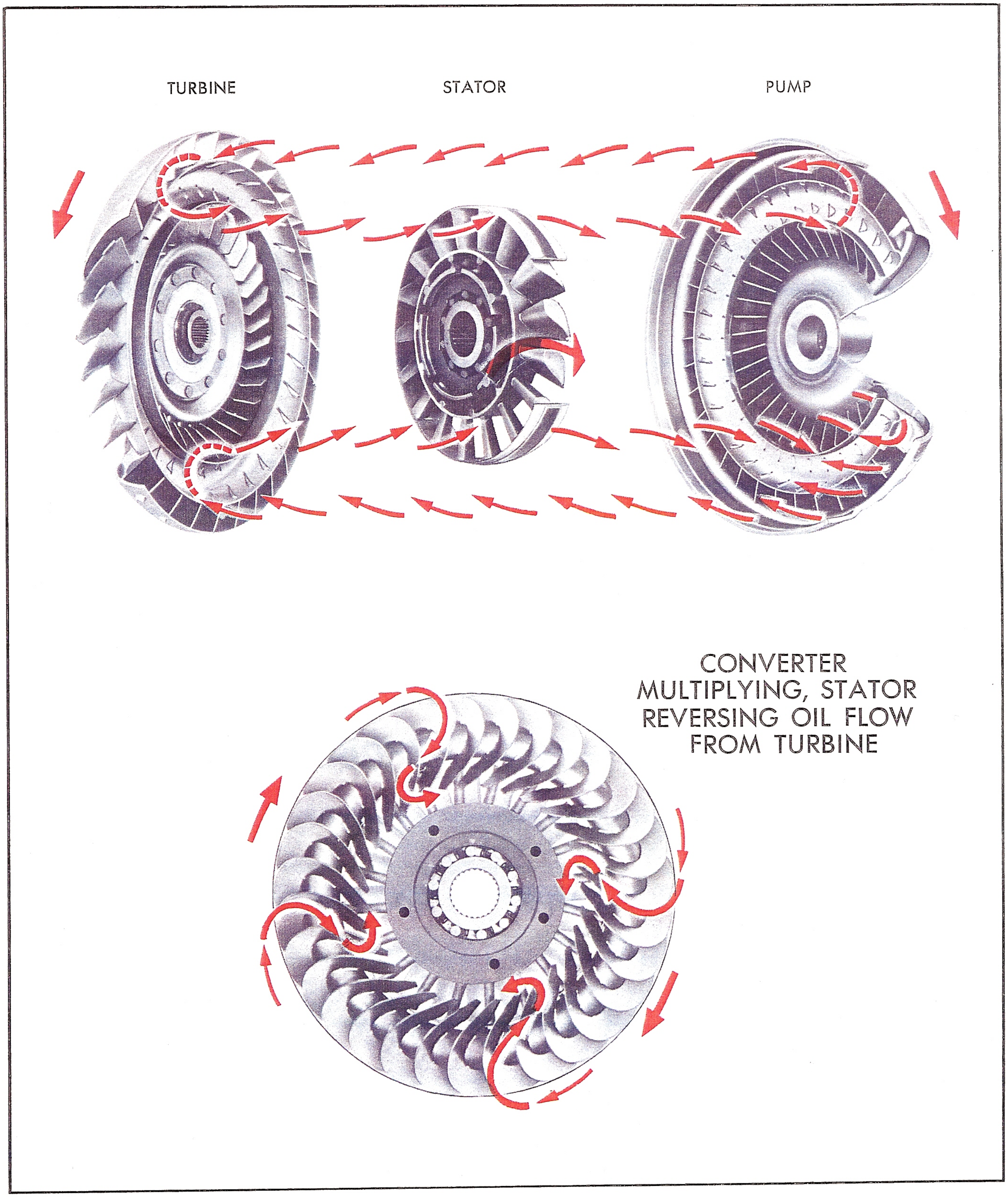



Fig. 9 Oil Flow with Stator Active

As turbine speed and vehicle speed increases, the direction of the oil leaving the turbine changes. (Fig. 10) The oil flows against the rear side of the stator vanes in a clockwise direction. Since the stator is now impeding the smooth flow of oil, its roller clutch automatically releases and the stator revolves freely on its shaft. Once the stator becomes inactive, there is no further multiplication of engine torque within the converter. At this point the converter is merely acting as a fluid coupling as both the converter pump and the turbine are turning at the same speed or at a 1:1 ratio.

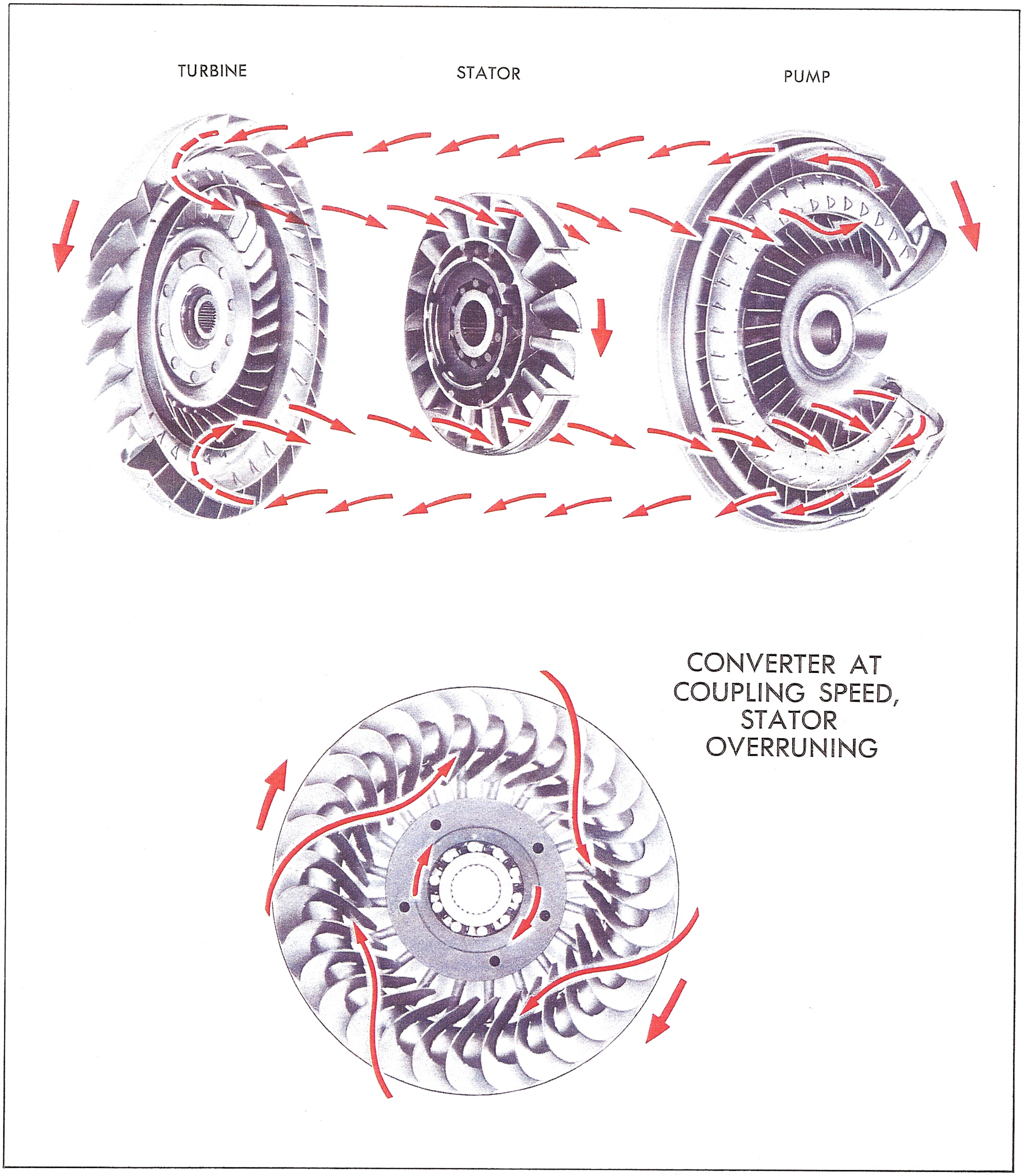



Fig. 10 Oil Flow with Stator Spinning

# POWER FLOW

| | ITEM |
|---|---|
| FIG. 11 | CONVERTER COVER AND PUMPS |
| FIG. 12 | TURBINE AND TURBINE SHAFT |
| FIG. 13 | STATOR ASSEMBLY |
| FIG. 14 | FORWARD CLUTCH ASSEMBLY |
| FIG. 15 | REAR UNIT GEAR SET |
| FIG. 16 | FRONT UNIT GEAR SET |
| FIG. 17 | ROLLER CLUTCH—LO |
| FIG. 18 | INTERMEDIATE CLUTCH ASSEMBLY |
| FIG. 18A | SPRAG ASSEMBLY |
| FIG. 19 | DIRECT CLUTCH ASSEMBLY |
| FIG. 20 | REAR BAND—REVERSE |
| FIG. 21 | FRONT BAND—2ND GEAR—INTERMEDIATE |
| FIG. 22 | REAR BAND—1ST GEAR—LO RANGE |

# POWER FLOW

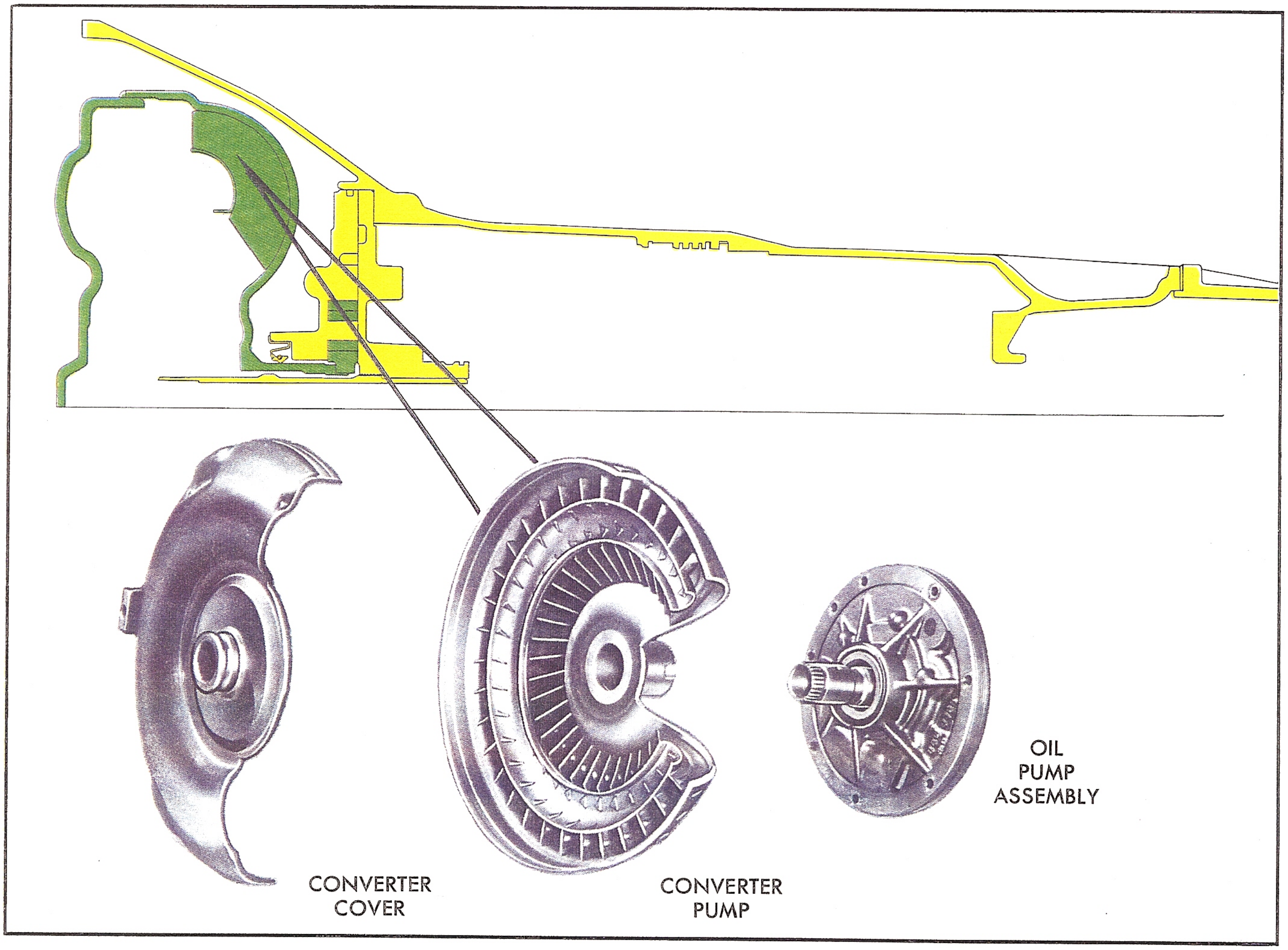



Fig. 11 Converter Cover and Pump, and Oil Pump

The power flow and the principles of operation of the Hydra-matic 400 transmission power train are most easily understood when each unit or component is considered separately with a part by part build up of the total unit.

The torque converter is connected to the engine by means of a flex-plate. The flex-plate is bolted directly to the engine crankshaft and to the converter cover by three mounting lugs. (Fig. 11) The converter cover is welded to the converter pump member, thus providing a direct connection of the engine to the converter. The converter pump hub fits into the transmission oil pump and drives the oil pump whenever the engine is operating.

The converter driven member or turbine is located within the converter housing in front of the pump member. (Fig. 12) Its blades face the pump blades. As the pump member turns with oil in the converter, the force of the oil from the pump strikes the blades of the turbine thus imparting a driving force causing it to turn. A turbine shaft is splined into the turbine hub and delivers the converter's output torque to the transmission power train.

The converter stator assembly is installed between the turbine and the pump member. (Fig. 13) It is located so that its blades receive the oil as it passes from the turbine to the pump. A stator shaft, which is an integral member of the transmission oil pump cover, supports the stator assembly and provides the support for the fixed or inner race of the roller clutch assembly. The oil flow which tends to rotate the stator counter-clockwise, locks the roller clutch and holds the stator in place. Oil flow from the turbine that tends to turn the stator clockwise causes the roller clutch to free wheel or overrun, allowing the stator to rotate freely with the oil.

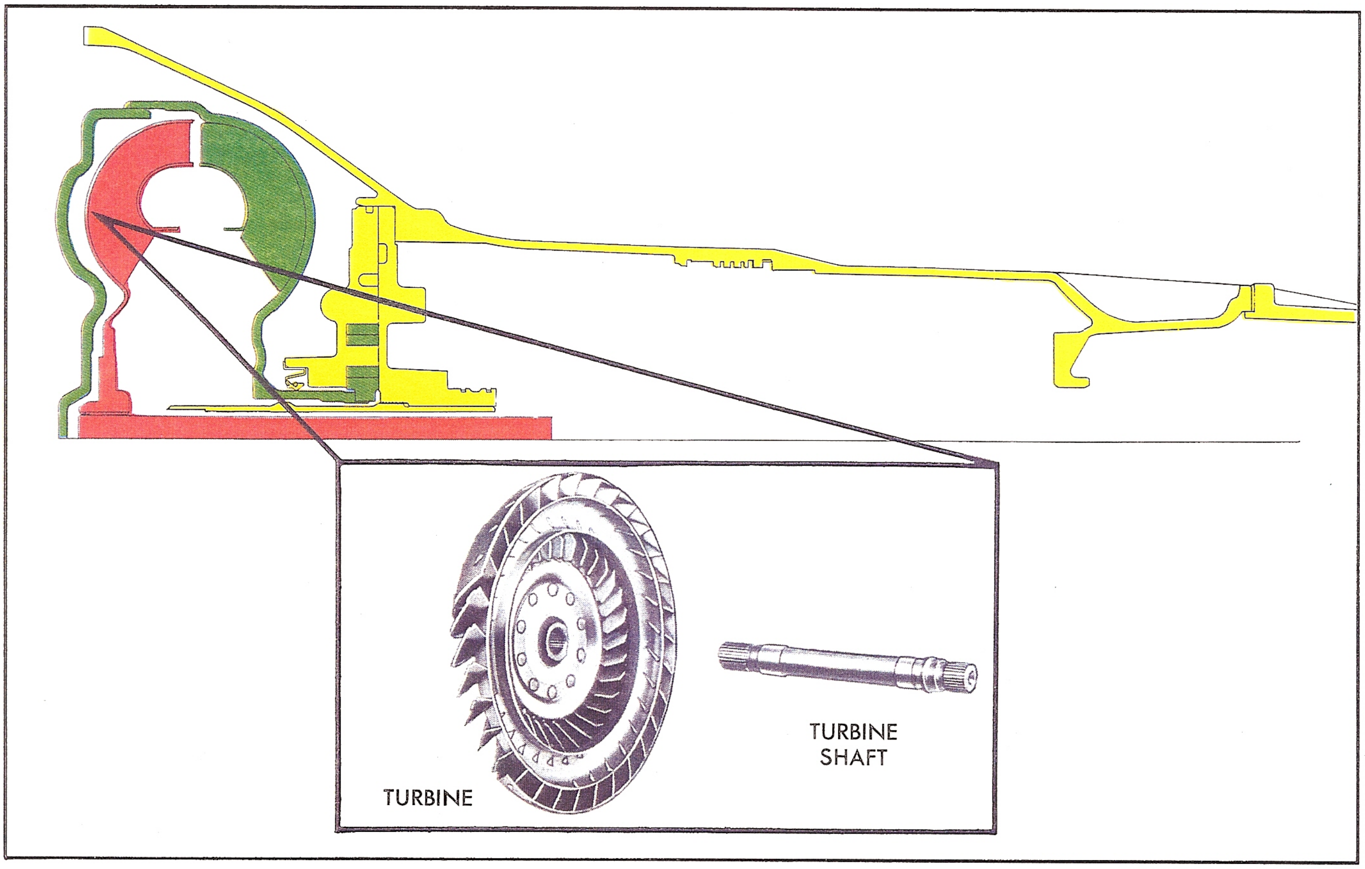



Fig. 12 Turbine and Turbine Shaft

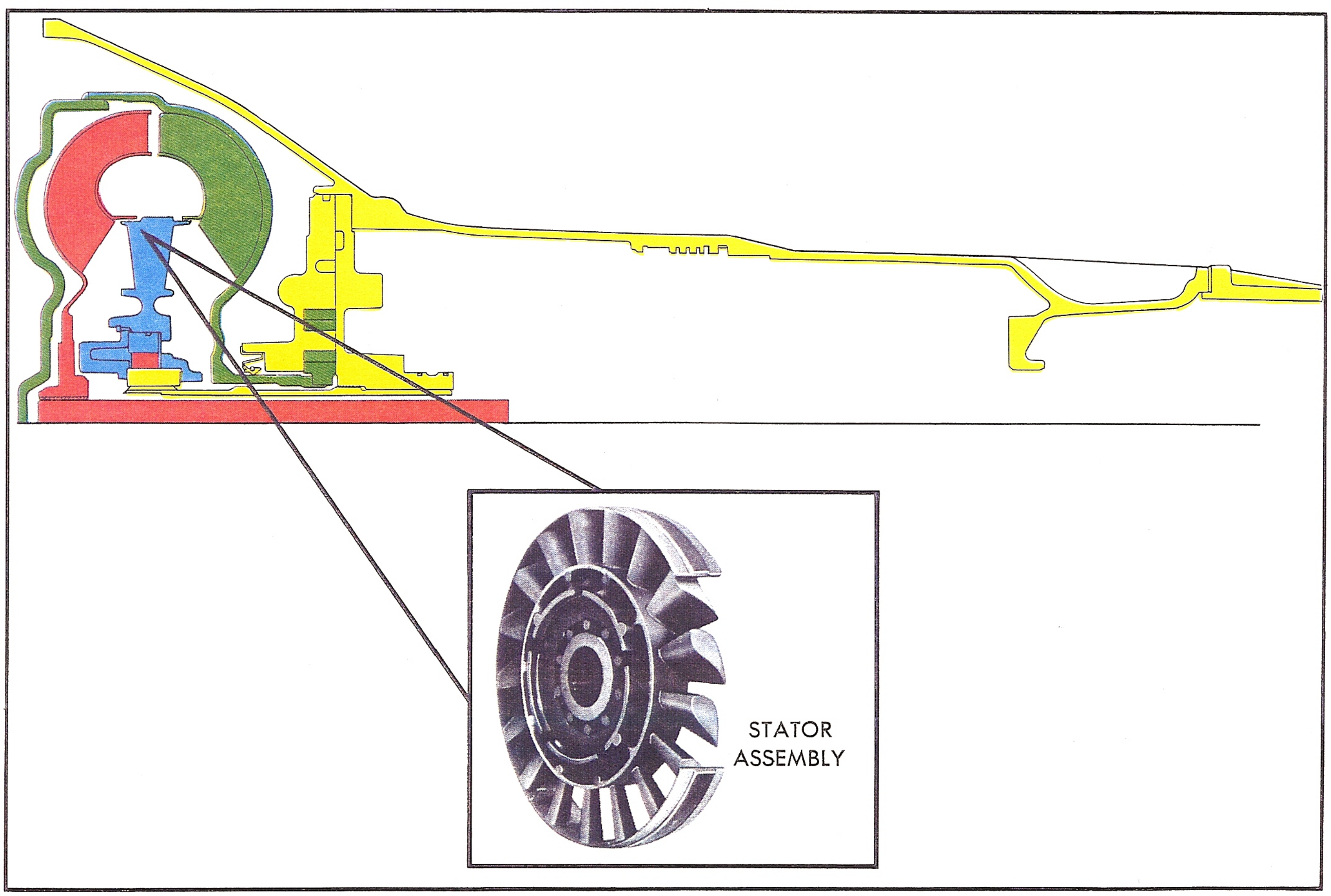



Fig. 13 Stator Assembly

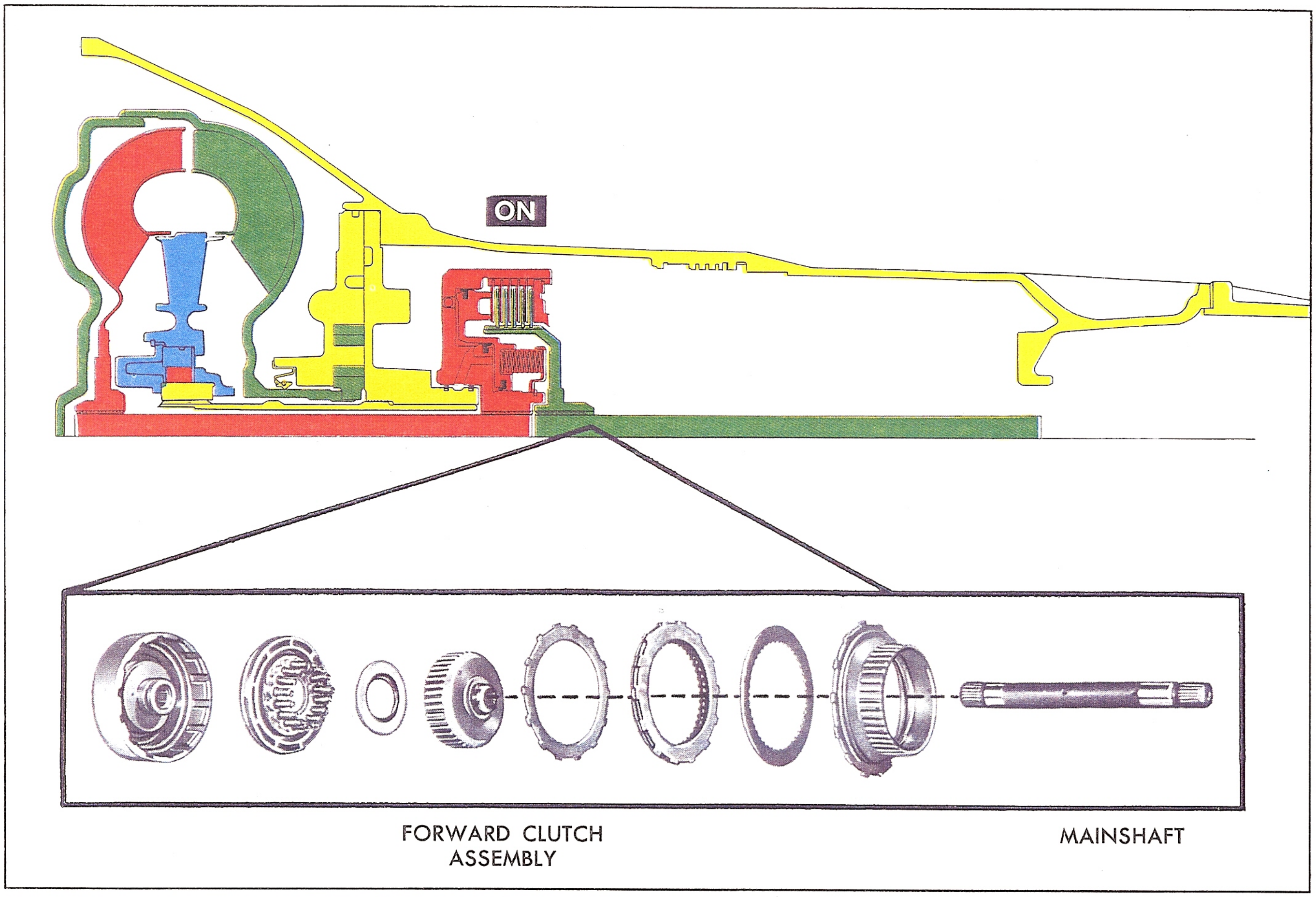



Fig. 14 Forward Clutch Assembly and Mainshaft

Actually, the torque converter and turbine shaft form a simple type of transmission in themselves as the pump cover is the input and the turbine shaft the output. The needs of an automobile transmission are greater, however, in that some means of providing additional torque multiplication, reverse, and neutral are required.

To provide a means of connecting and disconnecting power output from the converter to the transmission gear train a forward clutch is used. (Fig. 14) The forward clutch is composed of a forward clutch housing which is splined to the turbine shaft; steel clutch plates which are tanged into the forward clutch housing; composition-faced clutch plates that are tanged to a clutch hub; a clutch piston that hydraulically applies to lock the plates together; and clutch release springs that retract the piston to release the clutch when the hydraulic pressure is released. The mainshaft is splined to the forward clutch hub. Whenever the forward clutch is applied, power from the converter turbine shaft is connected to the transmission mainshaft. Releasing the forward clutch interrupts the connection between the converter and the mainshaft placing the transmission in neutral.

The mainshaft is connected to the compound planetary gear train. (Fig. 15) The rear unit consists of an internal gear which is splined to the mainshaft; the output planet carrier and pinions; the output shaft which is connected to the output carrier; and the sun gear. Power through the mainshaft causes the internal gear to drive in a clockwise direction. This rotates the pinions as idlers in a clockwise rotation and drives the sun gear in a counter-clockwise direction.

The rear sun gear and front sun gear are made as one piece so the front sun gear now turns counter-clockwise. (Fig. 16) This drives the pinions in the front unit in a clockwise rotation on their pins, which in turn apply a force that tends to drive the front internal gear clockwise. The front internal gear is part of the rear or output carrier and is thus connected to the output shaft. This reacts with a force on the front pinions that is trying to drive the front internal gear clockwise. This reaction wants to spin the entire front carrier assembly counter-clockwise instead of allowing the force to turn the internal gear and output shaft against the weight of the vehicle. To make the gear set effective in driving the vehicle, something has to hold the front or reaction carrier stationary.

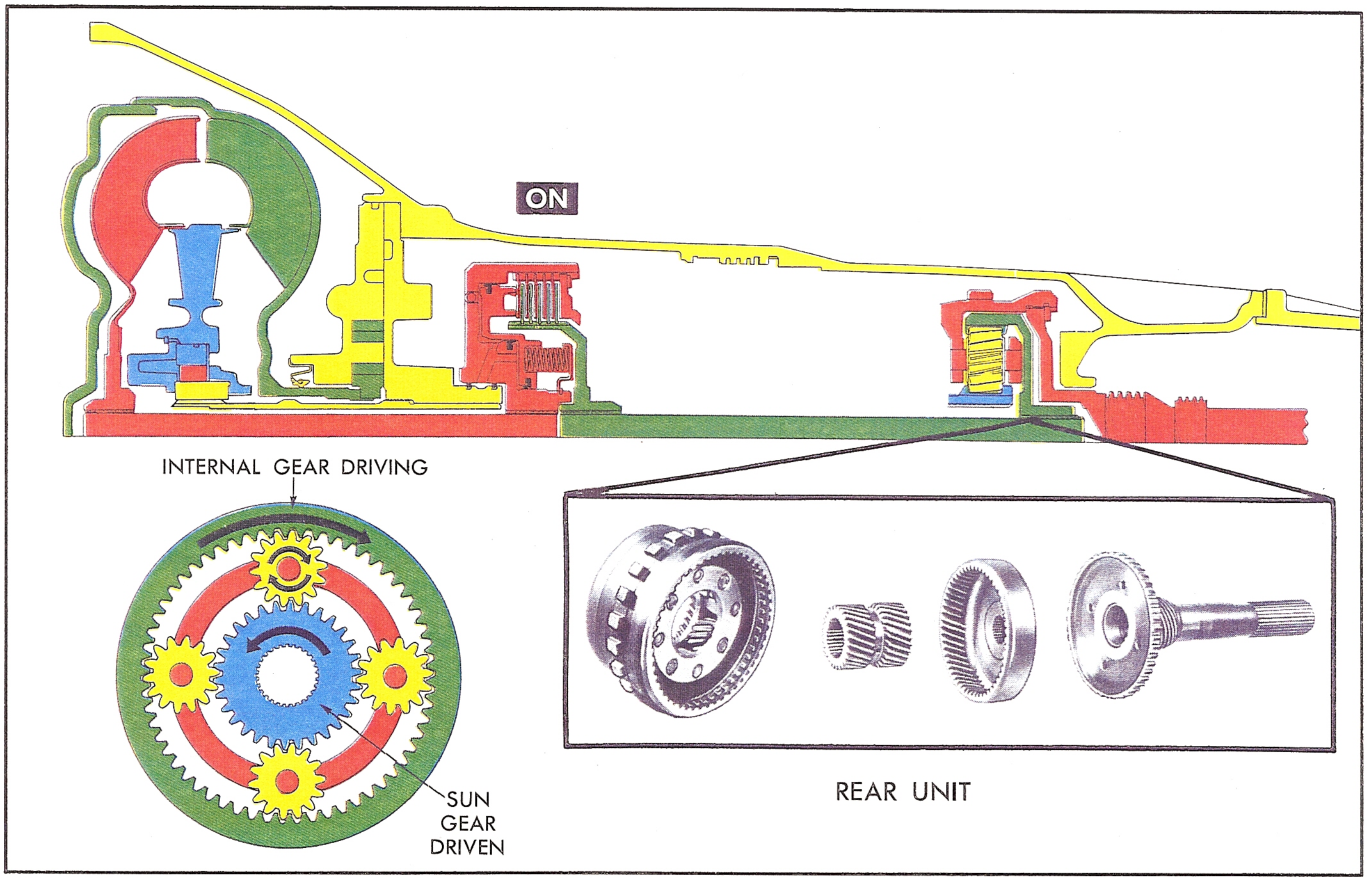



Fig. 15 Rear Unit Gear Set

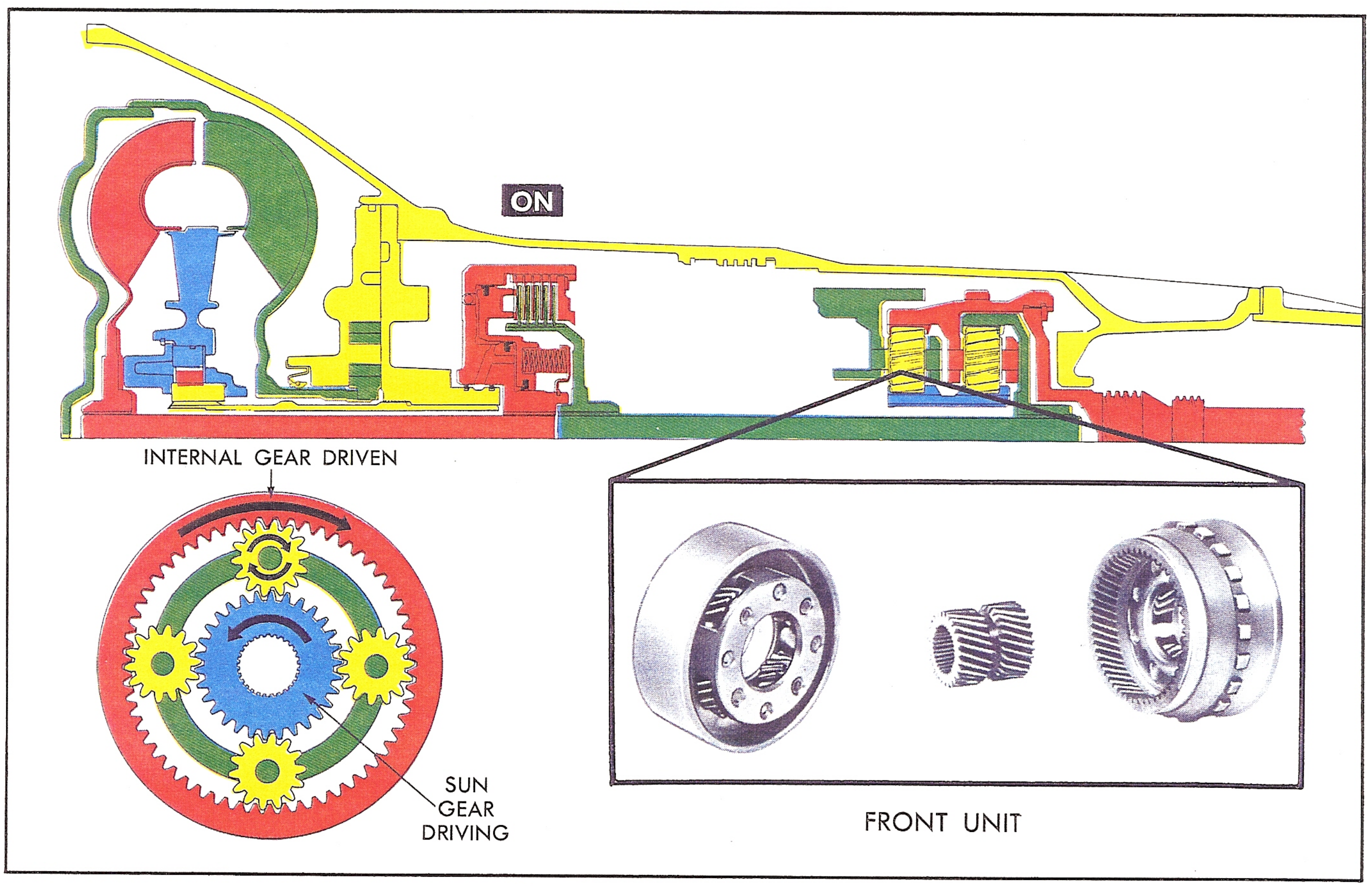



Fig. 16 Front Unit Gear Set

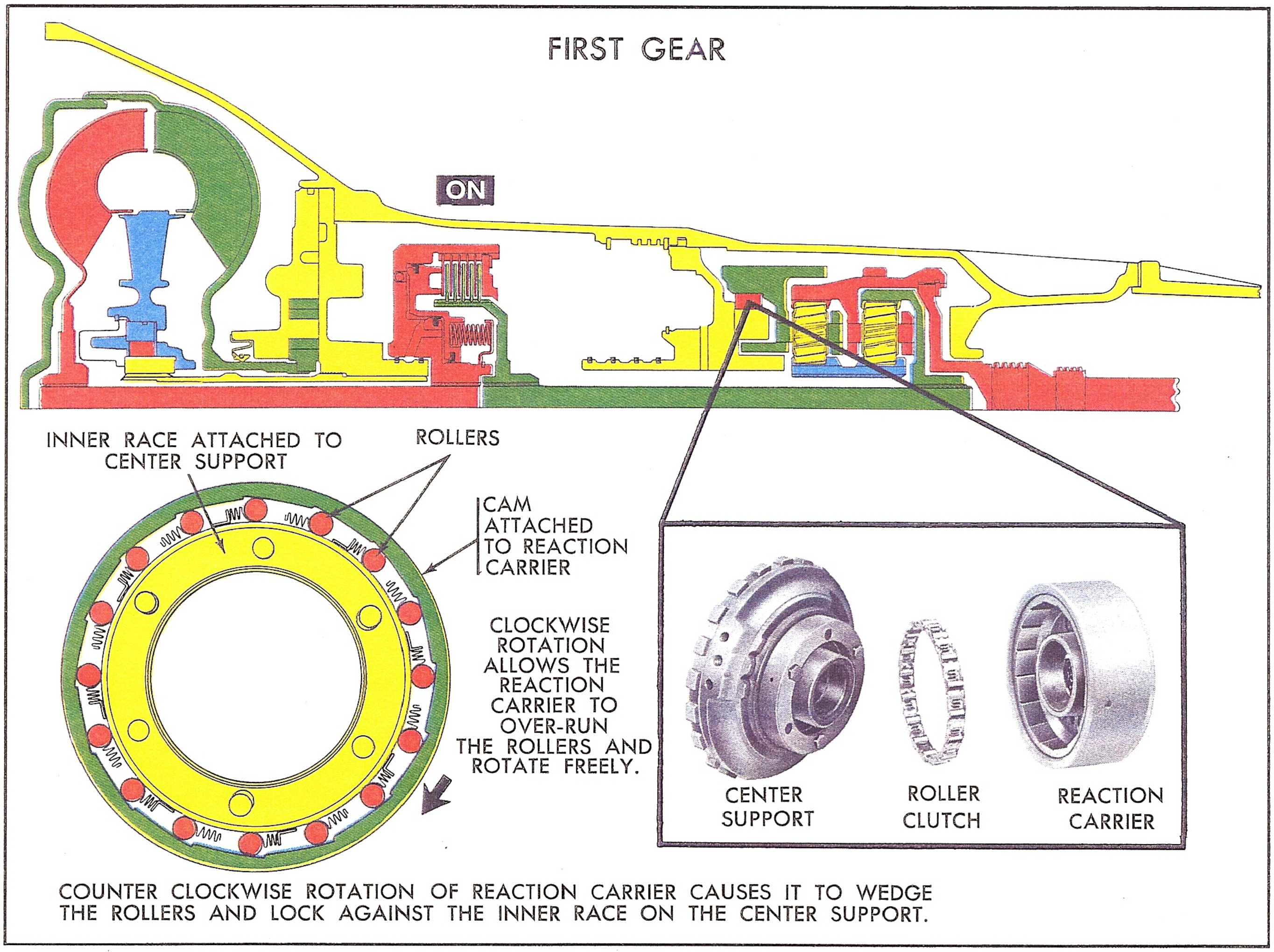



Fig. 17 Lo Roller Clutch

To hold the reaction carrier fixed against counter-clockwise rotation, a roller clutch assembly is used. (Fig. 17) A roller clutch assembly is a type of one-way clutch that allows a rotating part to turn in one direction but not in the other. In this application, the inner race is bolted and doweled to the transmission center support, which is keyed into the transmission case and bolted in place. The roller clutch assembly outer race is pressed into and doweled to the reaction drum which is part of the reaction carrier assembly.

The roller clutch assembly is installed between the races in such a way that its elements will lock and prevent the reaction carrier from rotating counter-clockwise. This provides the required reaction and causes the front planet pinions to drive the front internal gear and output shaft in reduction at a ratio of approximately 2.5:1. This gear reduction, combined with the maximum converter ratio of approximately 2:1, gives an over-all transmission first gear starting ratio of approximately 5:1.

As vehicle speed increases, less torque multiplication is desired for maximum efficiency. Thus, it is desirable to shift the transmission to a lower ratio or second gear. This is accomplished by adding the intermediate sprag assembly, the intermediate clutch, and sun gear shaft. (Fig. 18)

A sprag assembly is a device having irregular members wedged between two concentric members; it permits a part to rotate in one direction but not in the other. The sprag assembly consists of three parts, the inner race, the sprags and the outer race. (Fig. 18A)

The sun gear shaft is splined to the sun gear; the other end of the shaft is splined to the direct clutch housing. This housing has the intermediate sprag inner race splined and pressed onto its hub. The outer race of the sprag has splines which key to the composition-faced intermediate clutch plates. The steel clutch plates are splined directly to the transmission case. The intermediate clutch apply piston is located in the center support assembly.

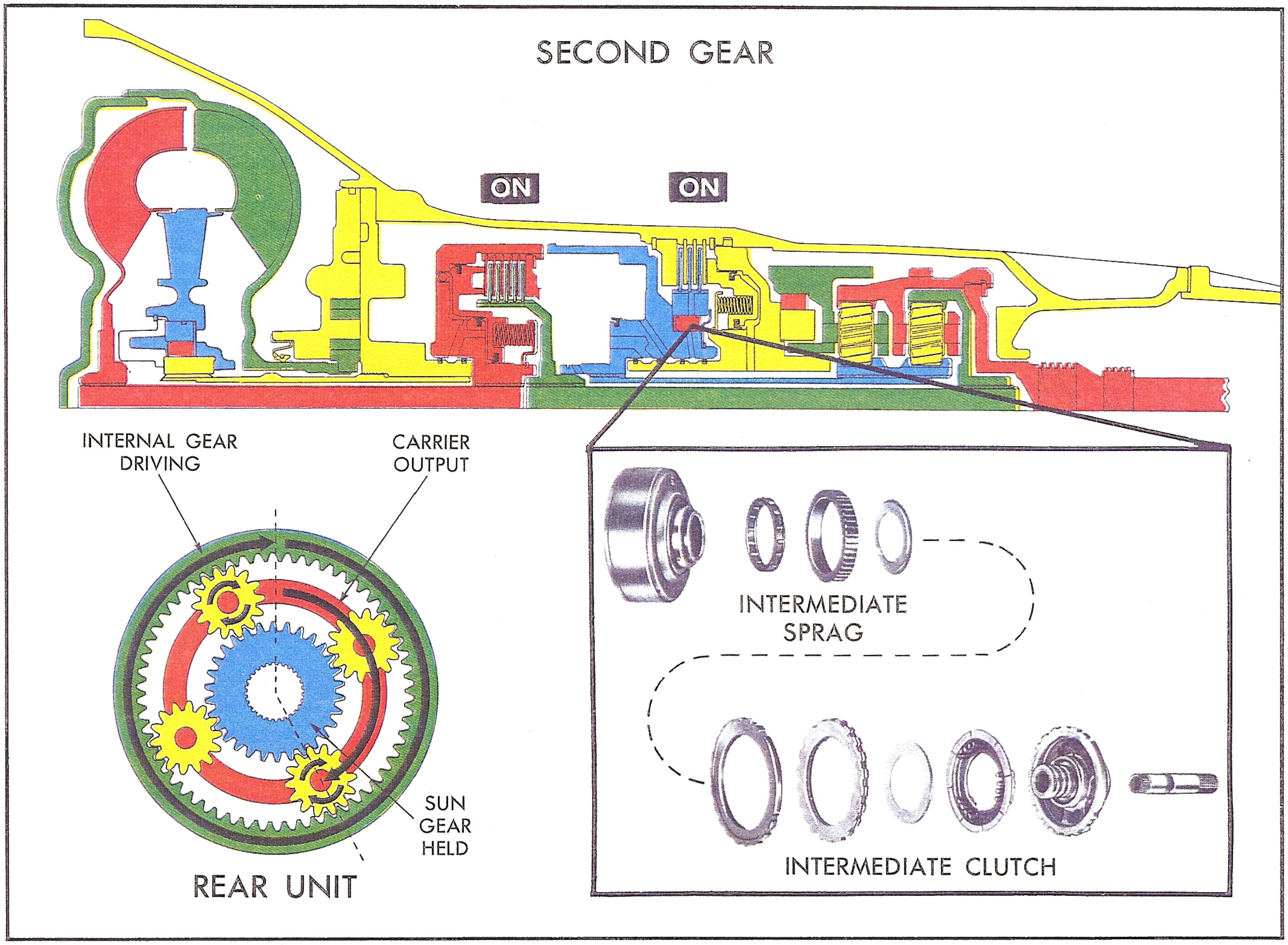



Fig. 18 Intermediate Sprag and Clutch Assembly

When the clutch is applied, the composition-faced intermediate clutch plates become locked to the steel clutch plates, thus locking the outer sprag race to the transmission case. This makes the sprag assembly effective in holding the clutch housing, shaft, and sun gear against counter-clockwise rotation.

When the sun gear is stopped, power flow becomes as follows:

> Converter output is transmitted through the forward clutch to the mainshaft and rear internal gear in a clockwise direction. As the rear internal gear turns clockwise, the rear pinions rotate clockwise on their pins and walk around the stationary sun gear. This moves the output carrier and output shaft in a clockwise direction in reduction with a gear ratio of approximately 1.5:1 or second gear.

The front unit is not used for second gear operation. However, because the output carrier is common with the front internal gear, the front internal gear is running clockwise in reduction.

This causes the front planet pinions to run clockwise around the stationary sun gear turning the reaction carrier clockwise. This clockwise rotation of the carrier causes the lo roller clutch assembly to over-run or to become ineffective.

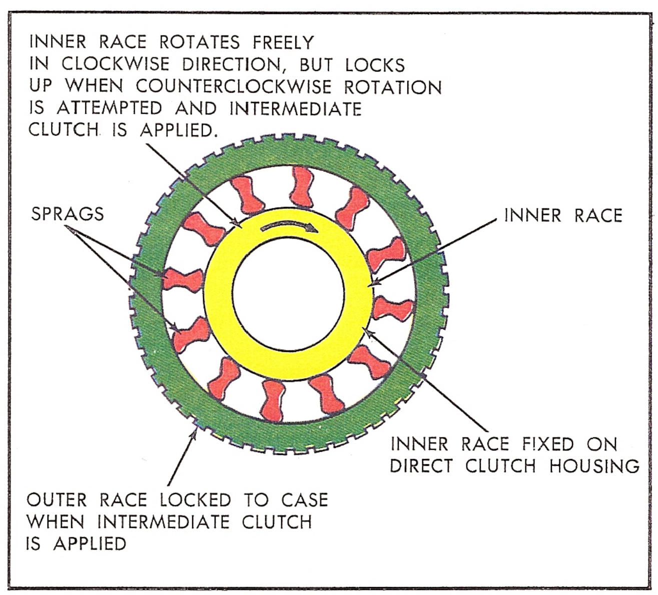



Fig. 18A Sprag Assembly

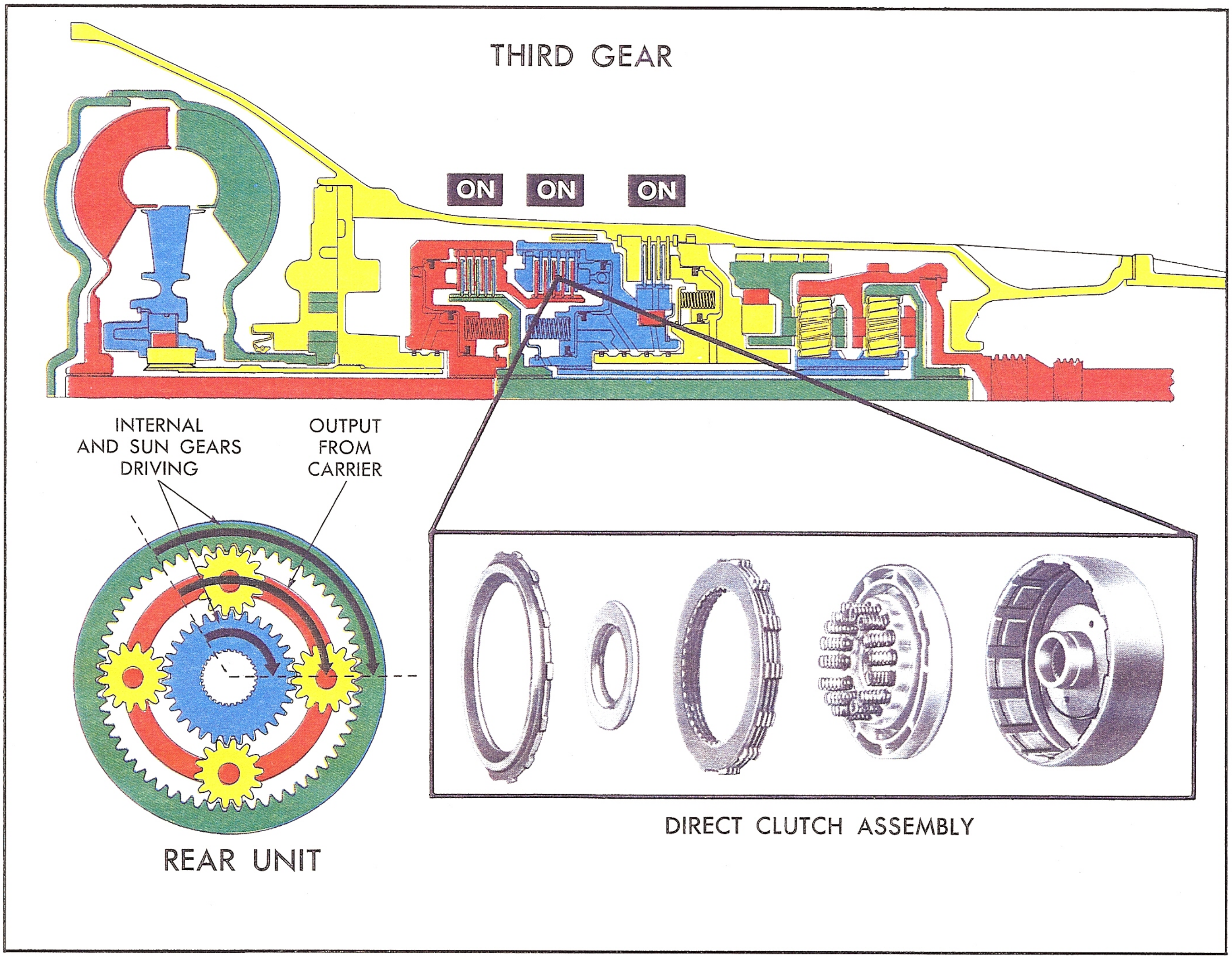



Fig. 19 Direct Clutch Assembly

As the vehicle continues to accelerate, a speed is attained where the 1. 5:1 transmission ratio is no longer required or desired. The transmission is then shifted to third gear or direct drive. Direct drive results when the rear internal gear and sun gear are driven at the same speed by the addition of a direct clutch assembly. (Fig. 19)

The direct clutch composition-faced clutch plates are splined to the hub which is part of the forward clutch backing plate. The steel clutch plates are splined to the direct clutch housing which is splined to the sun gear shaft. The clutch is hydraulically applied by a piston that is located in the direct clutch housing. When the clutch is applied, power from the forward clutch is divided to follow two paths to the gear set. First, the power continues through the forward clutch back to the mainshaft and rear internal gear. Second, power from the forward clutch is transmitted from its backing plate through the direct clutch to the sun gear shaft and sun gear. This forces the third member to turn at the same speed. In this condition, the pinions do not rotate on their pins but act as wedges to lock the entire unit together as one rotating part. As the direct clutch is applied, torque in a clockwise direction from the converter causes the intermediate inner sprag race to over-run the sprag assembly, thus rendering the sprag ineffective.

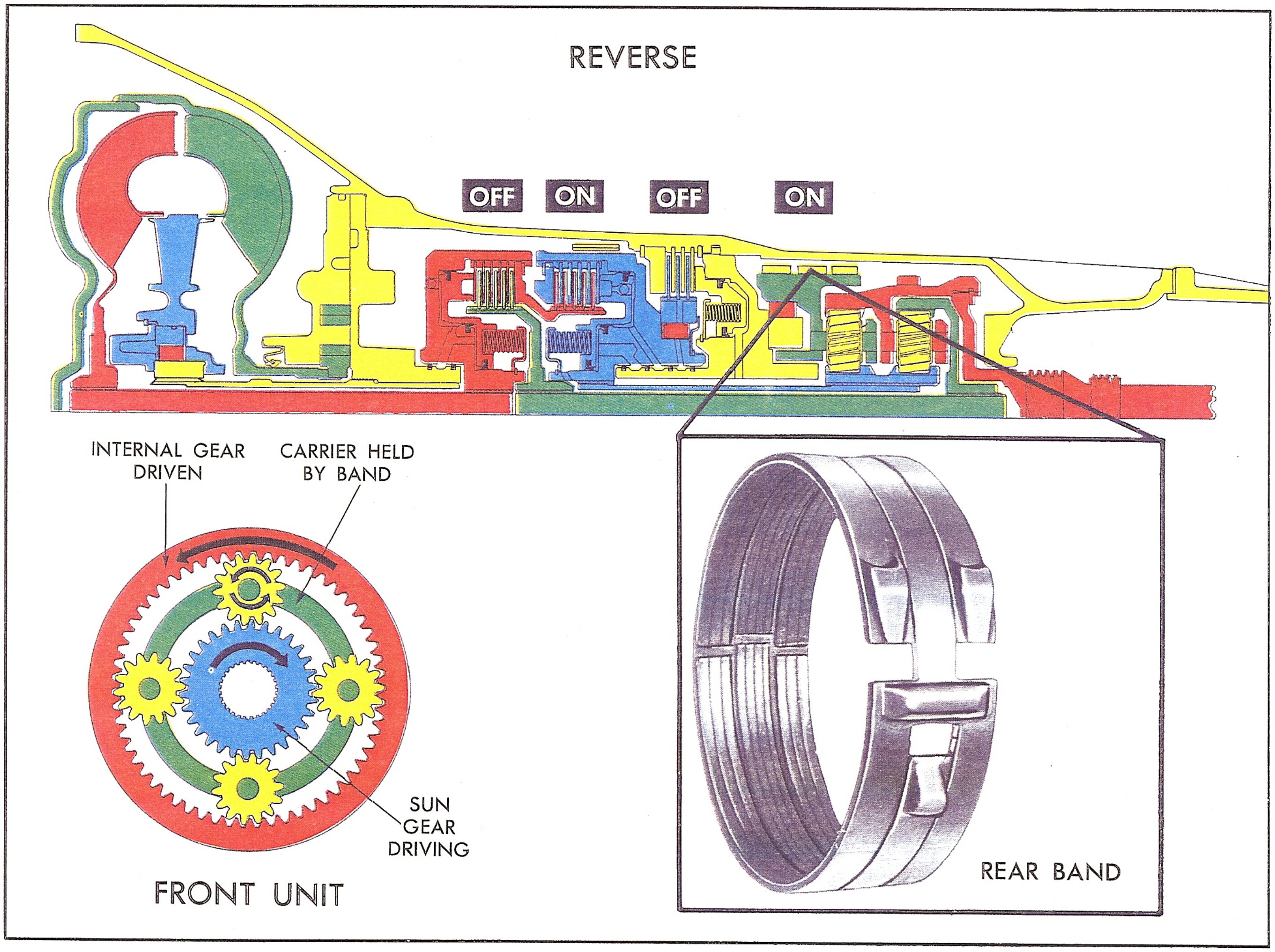



Fig. 20 Rear Band - Reverse

In order to obtain reverse operation, a rear band assembly is added. (Fig. 20) This band locks the reaction carrier against clockwise rotation which would cause the lo roller clutch to over-run. Power flow through the transmission in reverse is as follows: Turbine torque from the converter is transmitted to the forward clutch housing; the forward clutch is released, thus disconnecting flow of power to the mainshaft and rear internal gear. Instead of power flowing through the forward clutch, it flows from the turbine shaft through the forward clutch housing and through the direct clutch hub to the direct clutch. This applies power to the sun gear shaft and sun gear in a clockwise direction. With the sun gear driving clockwise, the front pinions revolve counter-clockwise as idlers. This drives the front internal gear and output shaft counter-clockwise or in a reverse direction. The over-all torque ratio in reverse, with maximum converter ratio and gear reduction, is approximately 4:1.

The Hydra-matic transmission and engine compression can also be used as an effective braking device when descending long grades. (Fig. 21) When the selector lever is placed in the Intermediate range, the transmission will shift immediately into second gear. With the accelerator released and the transmission in second gear, the vehicle will decelerate using engine compression as the braking force. In this situation, however, the rear wheels are driving the transmission through the output shaft. With the power being applied through the output shaft, there is a natural tendency for the intermediate sprag to over-run or become ineffective. To prevent the sun gear and direct clutch housing from over-running in this instance, a front band assembly is added and applied to the direct clutch housing. The front band holds the direct clutch housing stationary and keeps the transmission in second gear to provide effective braking.

For even greater engine braking, the transmission can be placed in Lo range. (Fig. 22) At speeds below approximately 40 mph, the transmission will shift to first gear. When the vehicle coasts in first gear, the lo roller clutch tends

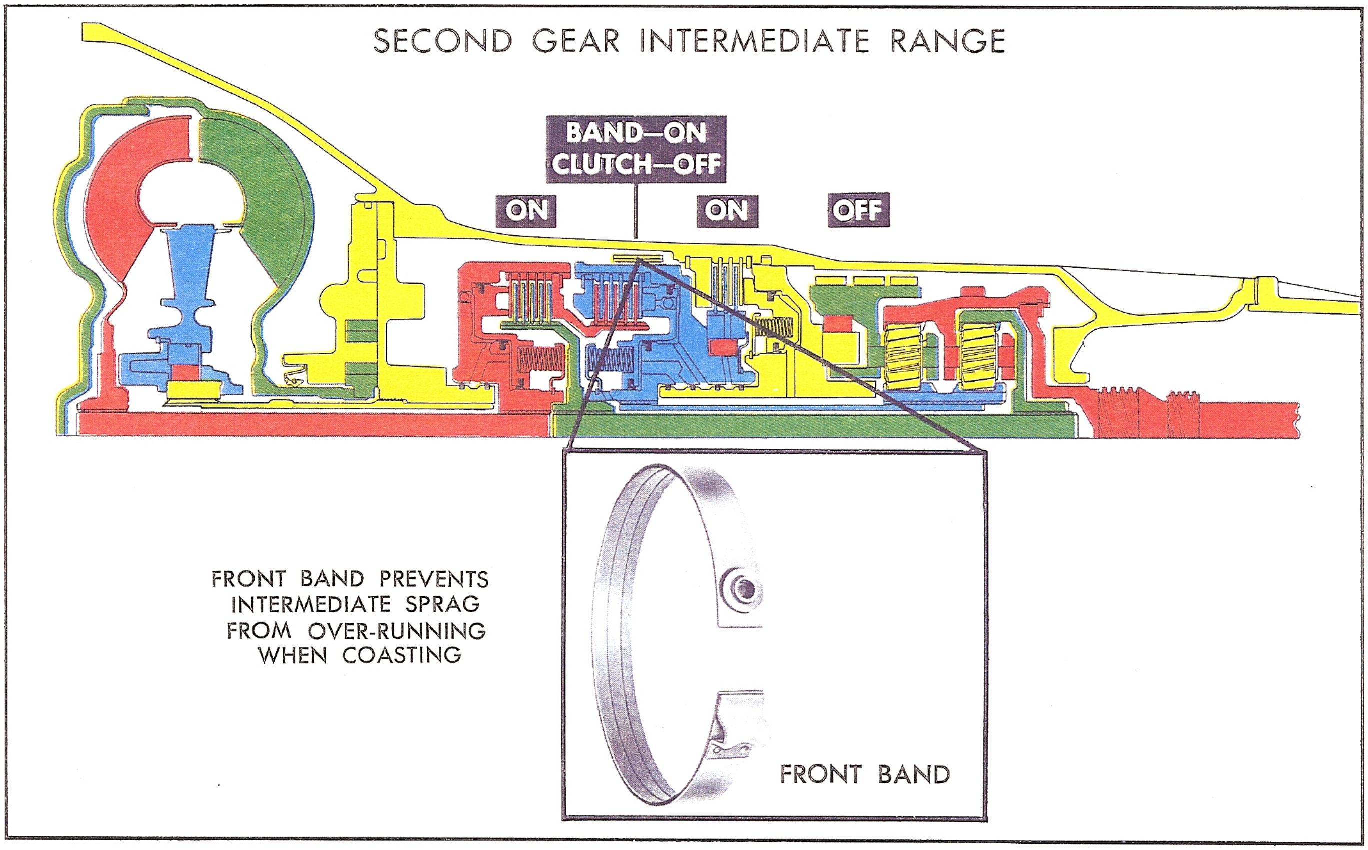



Fig. 21 Front Band - Second Gear Intermediate Range

to over-run. Therefore, the Lo-Reverse band is applied in first gear Lo range. This holds the reaction carrier stationary against over-running the lo roller clutch to keep the transmission in first gear.

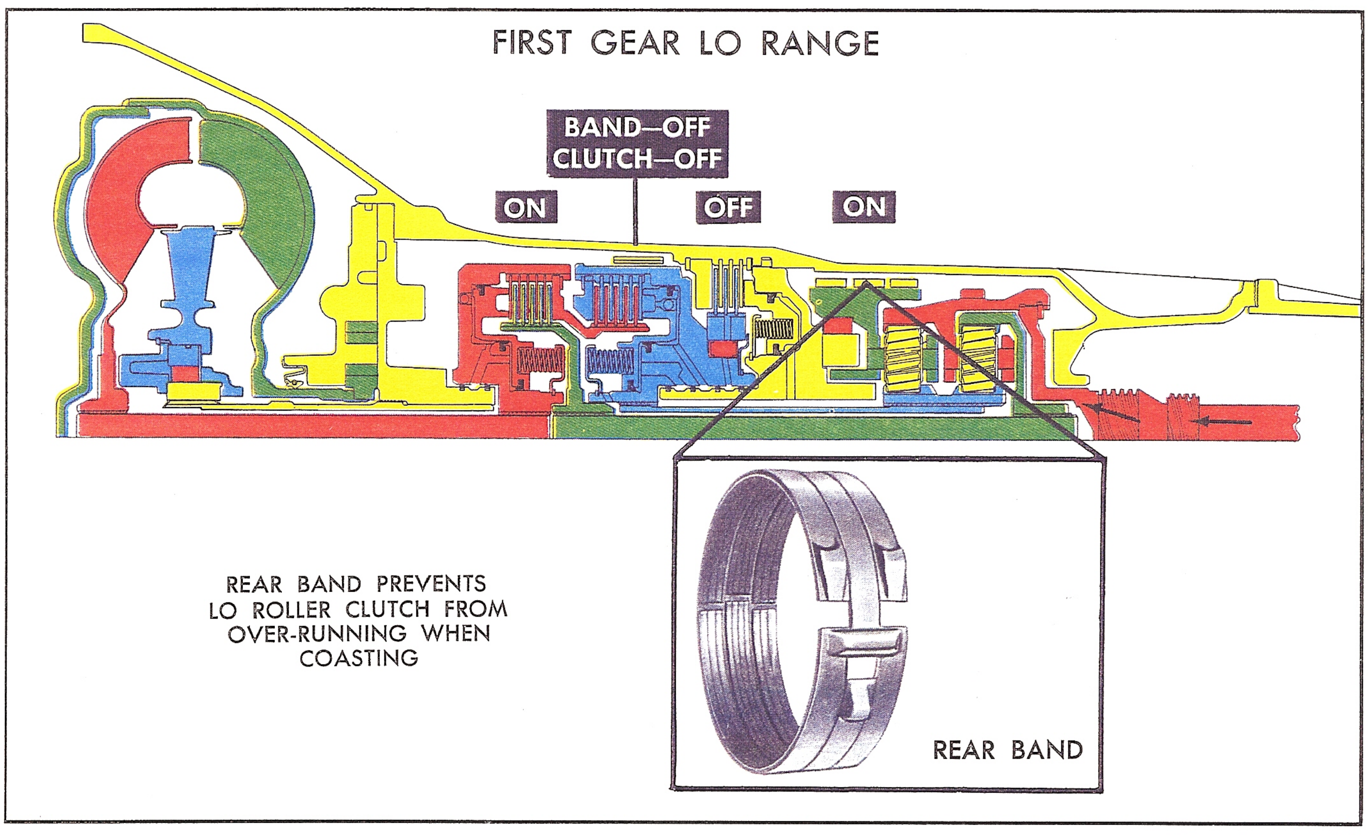



Fig. 22 Rear Band - First Gear Lo Range

# SUMMARY OF POWER FLOW

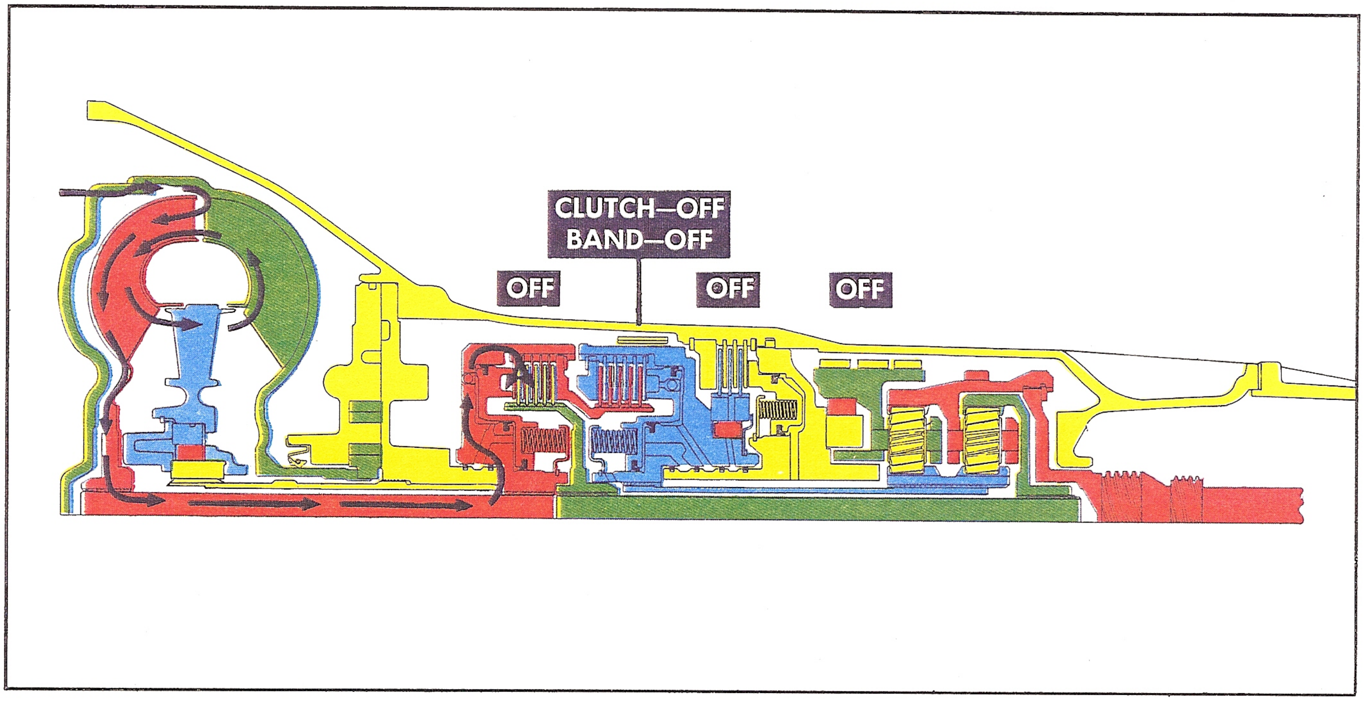



Fig. 23 Neutral - Engine Running

## NEUTRAL—ENGINE RUNNING

Forward Clutch - Released

Lo Roller Clutch - Ineffective

Direct Clutch - Released

Front Band - Released

Rear Band - Released

Intermediate Clutch - Released

Intermediate Sprag - Ineffective

In Neutral, all clutches and bands are released; therefore no power is transmitted from the torque converter turbine to the planetary gear train or output shaft. (Fig. 23)

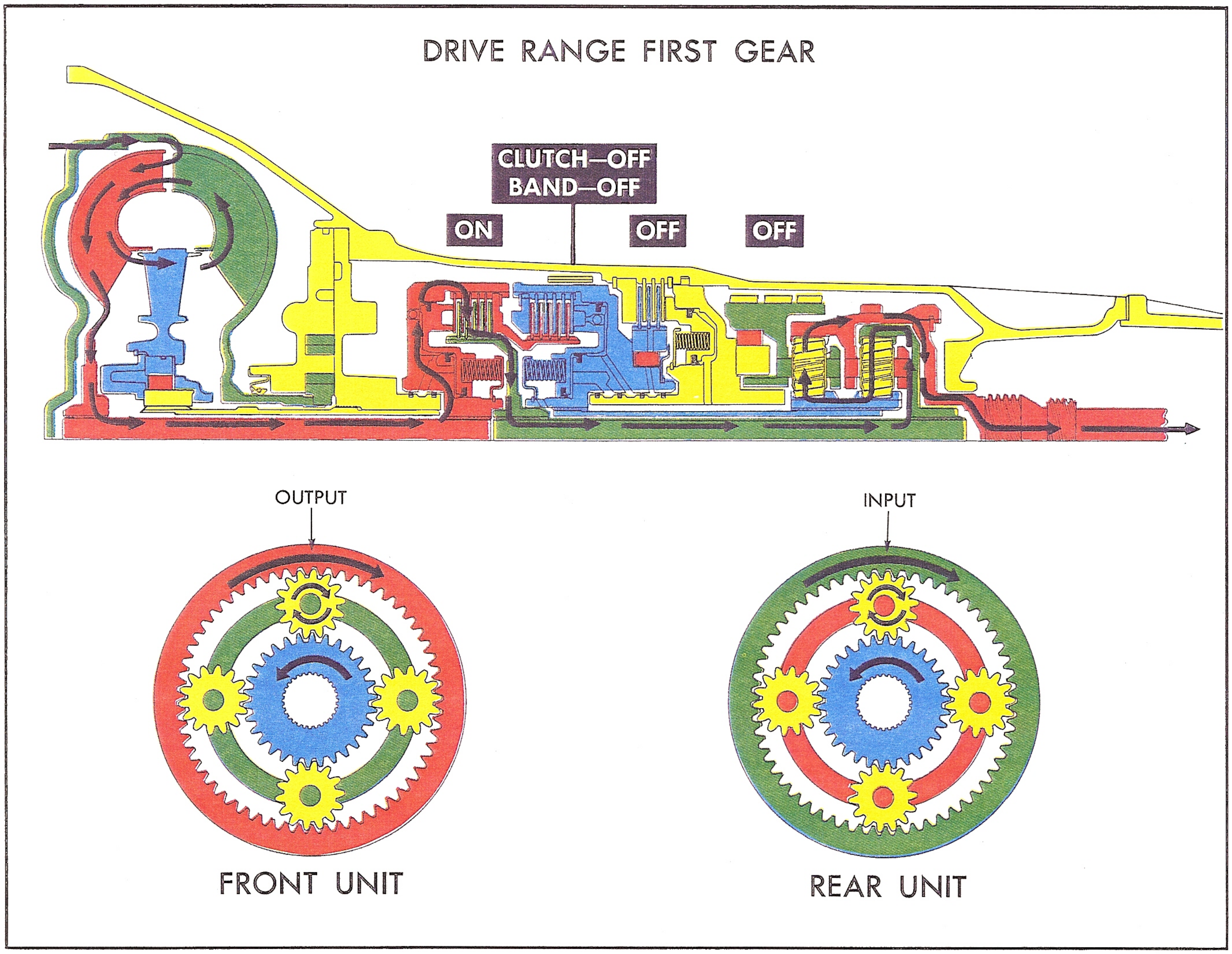



Fig. 24 Drive Range - First Gear

# DRIVE RANGE—FIRST GEAR

Forward Clutch - Applied

Lo Roller Clutch - Effective

Direct Clutch - Released

Front Band - Released

Rear Band - Released

Intermediate Clutch - Released

Intermediate Sprag - Ineffective

With the selector lever in Drive range, the forward clutch is applied. This delivers turbine torque to the mainshaft and turns the rear internal gear in a clockwise direction. (Converter torque ratio equals approximately 2:1 at stall) (Fig. 24)

Clockwise motion of the rear internal gear causes the rear pinions to turn clockwise, driving the sun gear counter-clockwise. In turn, the sun gear drives the front pinions clockwise, which drives the front internal gear, output carrier and output shaft clockwise in a reduction ratio of approximately 2.5:1. The reaction of the front pinions against the front internal gear is taken by the reaction carrier and lo roller clutch assembly to the transmission case. (Approximate stall ratio equals 5:1)

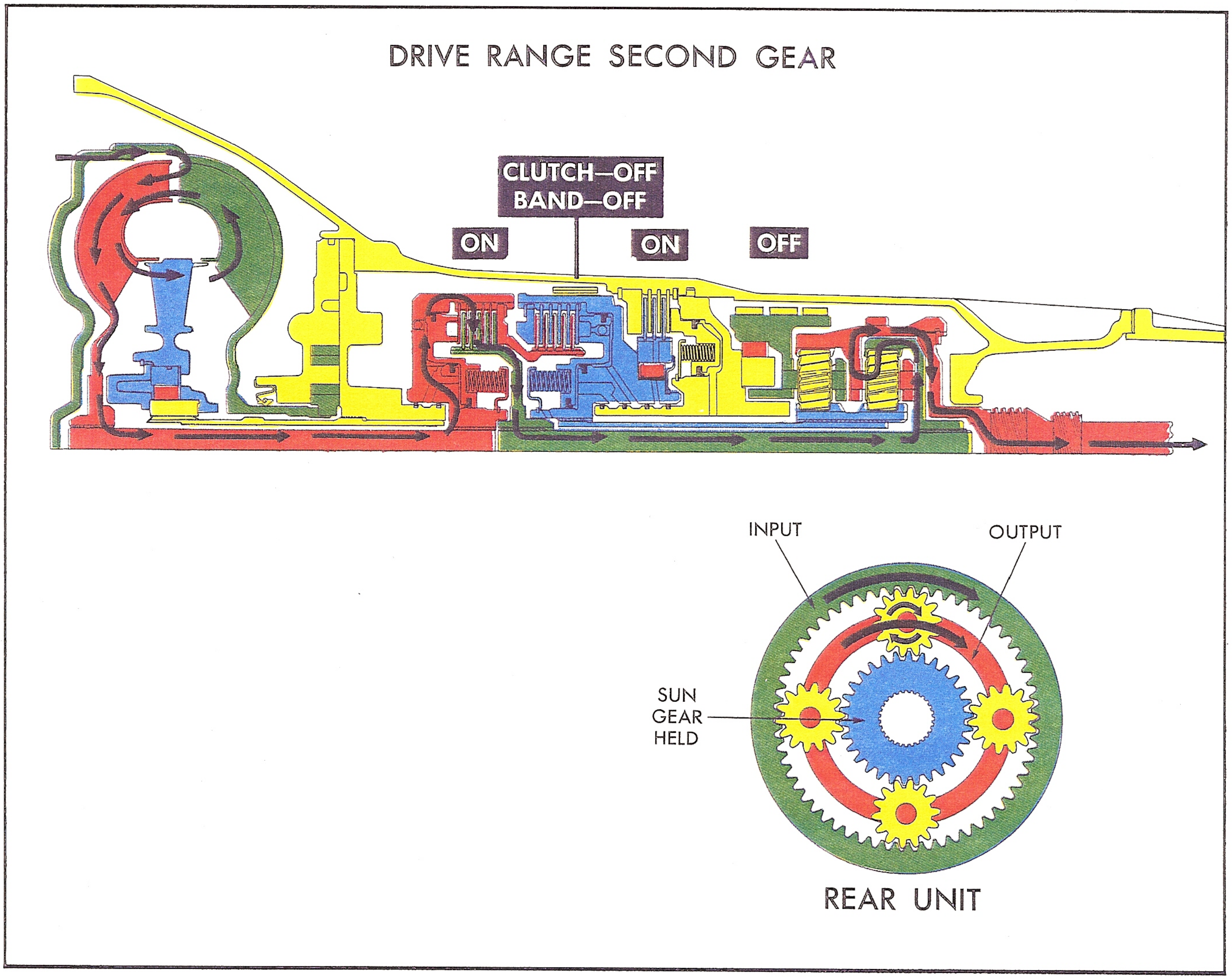



Fig. 25 Drive Range - Second Gear

# DRIVE RANGE—SECOND GEAR

Forward Clutch - Applied

Lo Roller Clutch - Ineffective (Over-Running)

Direct Clutch - Released

Front Band - Released

Rear Band - Released

Intermediate Clutch - Applied

Intermediate Sprag - Effective

In second gear, the intermediate clutch is applied to allow the intermediate sprag to hold the sun gear against counter-clockwise rotation. (Fig. 25) Turbine torque, through the forward clutch, is applied through the mainshaft to the rear internal gear in a clockwise direction. Clockwise rotation of the rear internal gear turns the rear pinions clockwise against the stationary sun gear. This causes the output carrier and output shaft to turn clockwise in a reduction ratio of approximately 1.5:1.

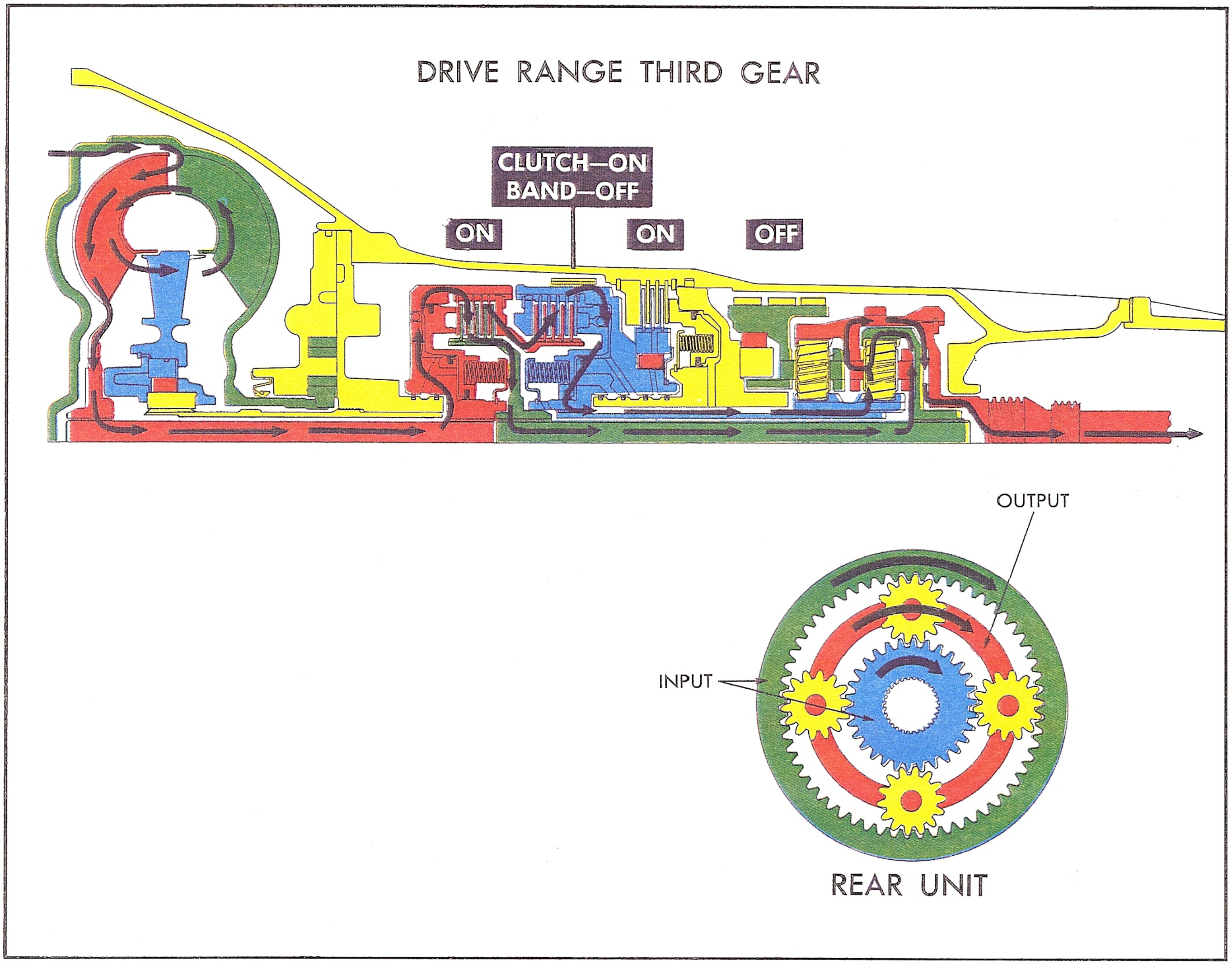



Fig. 26 Drive Range - Third Gear

# DRIVE RANGE—THIRD GEAR

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Applied | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective (Over-Running) | Front Band - Released | Intermediate Sprag - Ineffective (Over-Running) |
| | Rear Band - Released | |

In direct drive, engine torque is transmitted to the converter through the forward clutch to the mainshaft and rear internal gear. (Fig. 26) Because the direct clutch is applied, some power is also transmitted to the sun gear shaft and the sun gear. Since both the sun gear and internal gears are now turning at the same speed, the planetary gear set is essentially locked and turns as one unit in direct drive or at a ratio of 1:1.

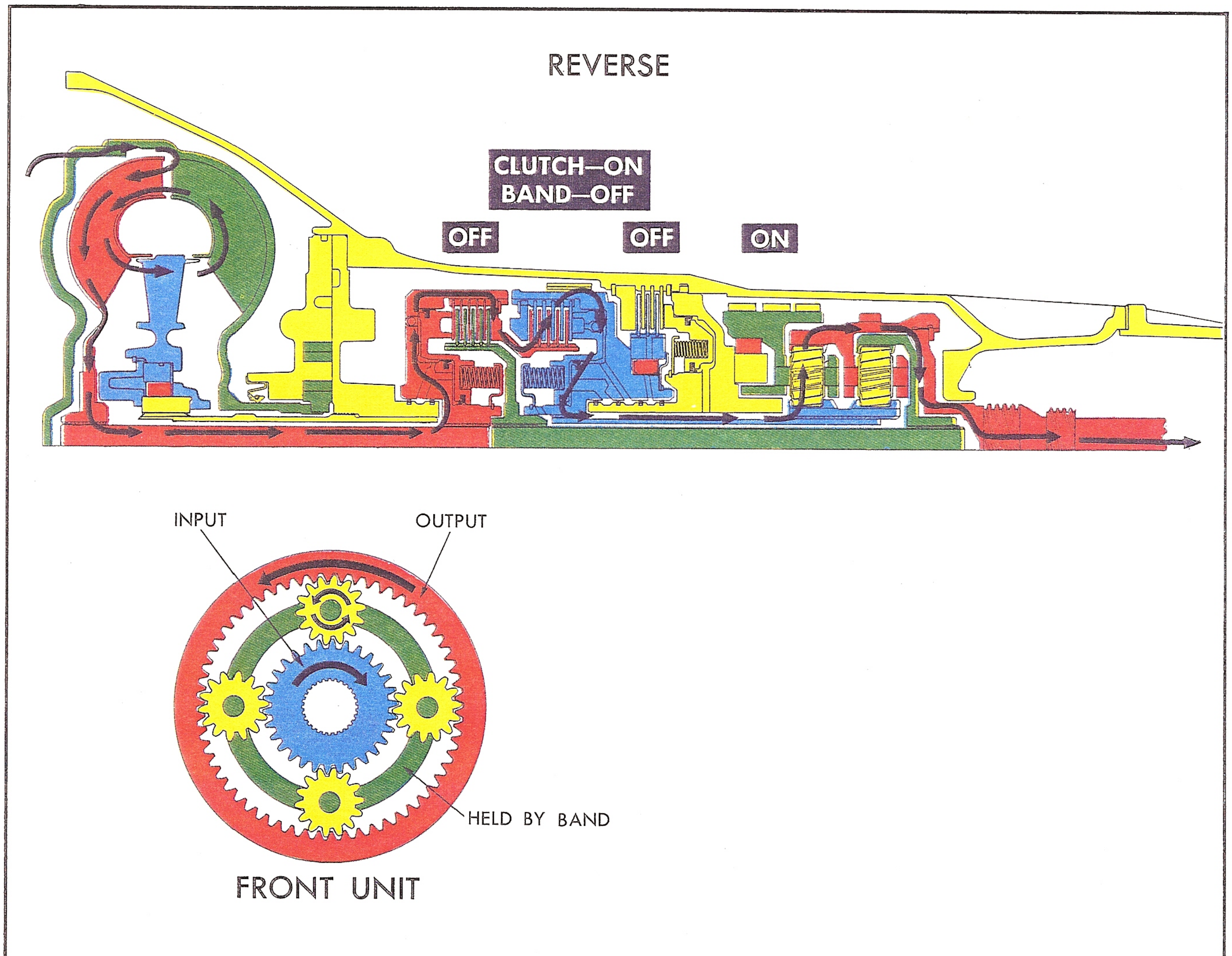



Fig. 27 Reverse

# REVERSE

| | | |
|---|---|---|
| Forward Clutch - Released | Direct Clutch - Applied | Intermediate Clutch - Released |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Ineffective (Over-Running) |
| | Rear Band - Applied | |

In Reverse, the direct clutch is applied to transmit turbine torque from the forward clutch housing to the sun gear shaft and sun gear. (Fig. 27) The rear band is applied; this prevents the reaction carrier from turning clockwise.

Clockwise torque to the sun gear causes the front pinions and front internal gear to turn counter-clockwise in reduction. The front internal gear is connected directly to the output shaft, thus providing the reverse output gear ratio of approximately 2:1. The reverse torque multiplication at stall (converter and gear ratios) is approximately 4:1.

# HYDRAULIC SYSTEM

In previous sections, the mechanical phase of the transmission operation has been described including references to the clutches and bands being hydraulically applied. The next section describes in detail the hydraulic system that applies the bands and clutches and controls automatic shifting.

the crescent, the gear teeth begin to come together causing the oil to be pressurized as it is squeezed from between the gear teeth. At this point, the oil is delivered through the pump outlet to the pressure system.

Oil pressure is controlled by the pressure regu-

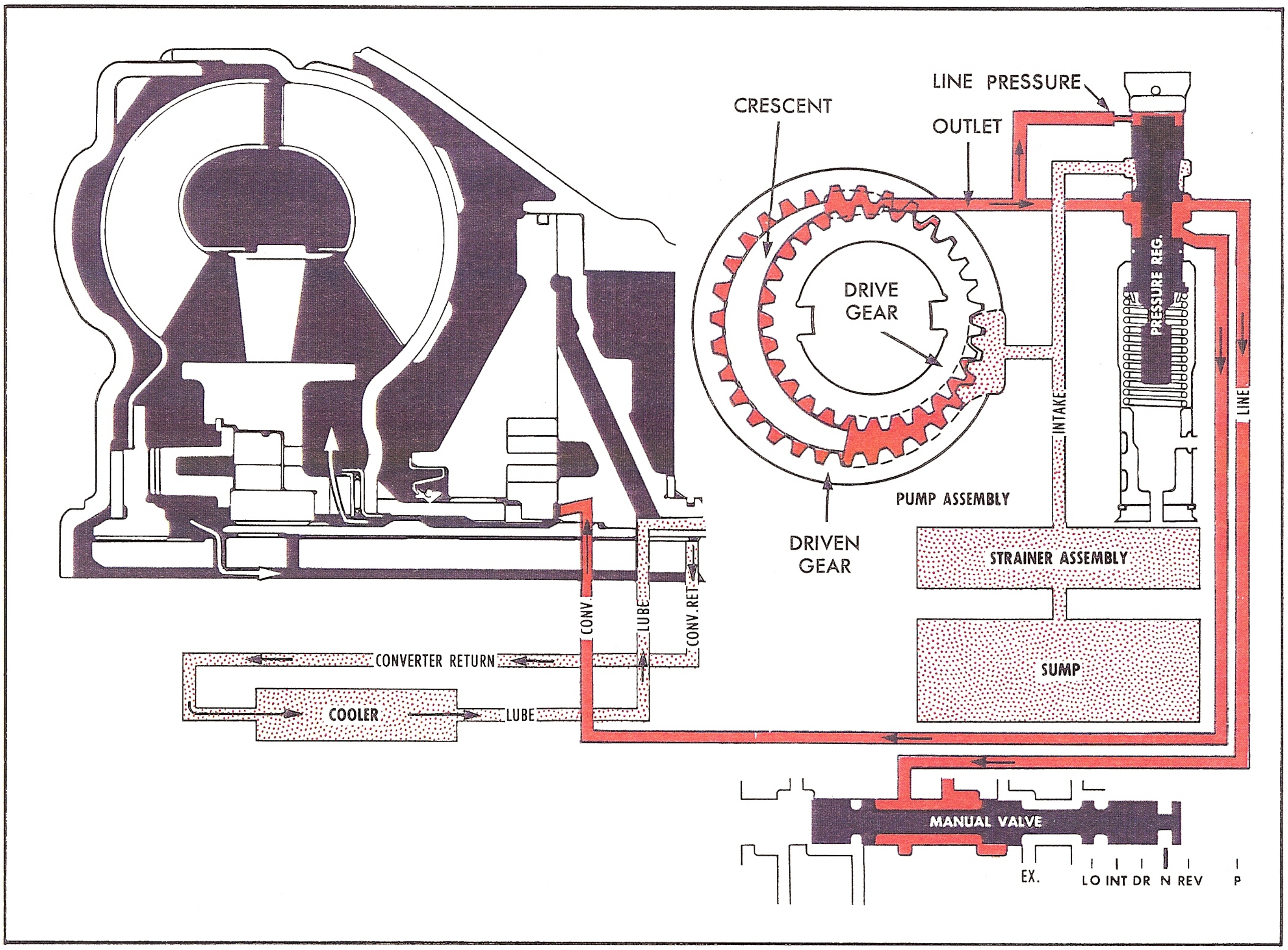



Fig. 28 Oil Pump and Pressure Regulating System

A hydraulic pressure system requires a source of clean hydraulic fluid and a pump to pressurize the fluid. The Hydra-matic 400 uses an internal-external gear type pump with its oil intake connected to a strainer assembly. (Fig. 28) The strainer intake draws oil from the transmission bottom pan or sump. The pump drive gear is keyed to the converter pump hub and therefore turns whenever the engine is operating. As the drive gear turns, it also turns the driven gear, causing oil to be lifted from the sump. As the gears turn, the oil is carried past the crescent section of the pump. Beyond

lator valve. As the pressure builds, oil is directed through an orifice to the top of the pressure regulator valve. When the desired pressure is reached, the valve moves down against the spring, thus opening a passage to feed the converter.

When the converter is filled, oil returning from the converter is directed to the transmission cooler in the engine radiator. Oil returning from the cooler is then directed to the transmission's lubrication system.

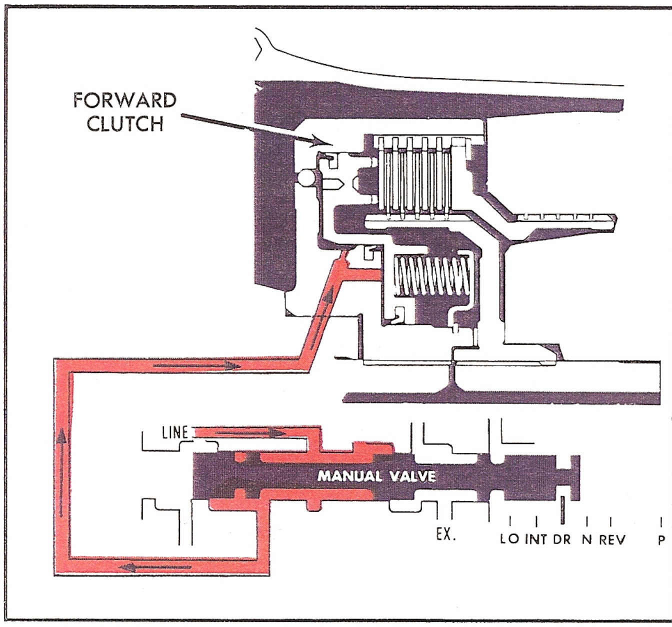



Fig. 29 Forward Clutch Applied

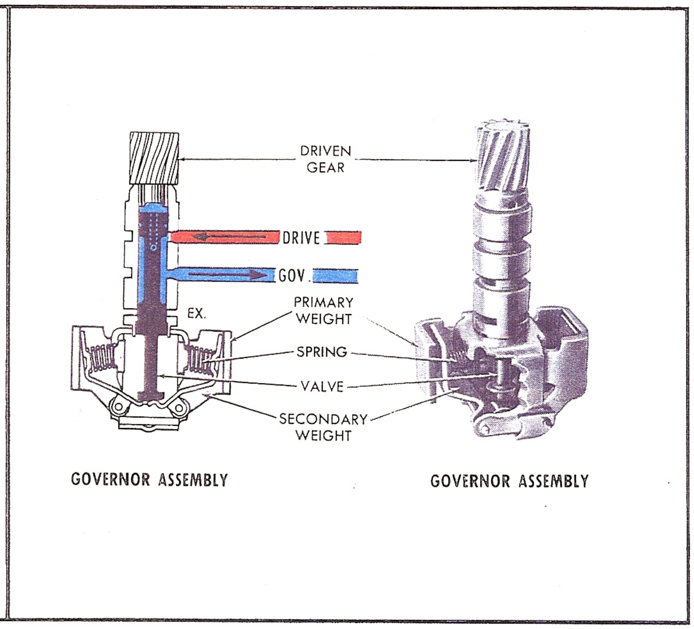



Fig. 30 Governor Assembly

As pressure continues to increase, the pressure regulator valve moves to expose a port that directs excess oil to the suction side of the pump. The pressure regulator valve is spring-balanced to regulate line pressure at approximately 70 psi.

When the transmission selector lever is moved to the D position, the manual valve moves to allow line pressure to be delivered to the forward clutch. The oil enters the small area first to provide a smooth initial apply. The larger area is then filled gradually by oil metered through an orifice to provide the final holding force required. (Fig. 29)

With the forward clutch applied, the mechanical connection for torque transmission between the turbine shaft and mainshaft has been provided. The lo roller clutch assembly becomes effective as a result of the powerflow through the compound planetary gear set and the transmission is in first gear ready for the vehicle to start moving.

As the vehicle begins to accelerate and first gear reduction is no longer required, the transmission automatically shifts to second gear.

The vehicle speed signal for the shift is supplied by the transmission governor which is driven by the output shaft. (Fig. 30) The governor assembly consists of a regulating valve, a pair of primary weights, a pair of secondary weights, the secondary springs, the body, and the driven gear. The weights are so arranged that the secondary weights act only on the valve. The primary weights add their effect to the secondary weights through the secondary springs. Because centrifugal force varies with weight and speed squared, small changes in output shaft rpm at low speed result in small governor pressure changes. To give even greater changes in pressure, the primary weight adds its heavy force to the secondary weight. This allows greater governor pressure changes. As the primary weight moves out at greater vehicle speeds, it finally reaches a stop and is no longer effective. From this point on, only the secondary weights and secondary springs are used to apply the force to the governor valve.

Drive oil pressure is fed to the governor. This in turn is regulated by the governor valve and gives a governor pressure that is proportional to vehicle speed.

To initiate the shift from first to second gear, governor pressure is directed to the end of the 1-2 shift valve where it acts against the spring pressure holding the valve in the closed position blocking drive oil. (Fig. 31) As the vehicle speed and governor pressure increase sufficiently to overcome spring force, the 1-2 valve train opens allowing drive oil to flow into the intermediate clutch passage and through an orifice to apply the intermediate clutch. This makes the intermediate sprag effective which shifts the transmission into second gear. Further increases in vehicle speed and governor pressure will cause the transmission to shift to third gear.

allowed to decelerate to a stop, the transmission automatically downshifts 3-2 and 2-1. This is accomplished by the decrease in governor pressure as the vehicle slows and the springs closing the shift valve trains in sequence.

In this system, the 1-2 and 2-3 shifts will always take place at the same vehicle speeds whenever the governor pressure overcomes the force of the springs on the 1-2 and 2-3 shift valves. When accelerating under a heavy load or for maximum performance, it is desirable to have the shifts occur at higher vehicle speeds. To make the transmission shift at higher vehicle speeds with greater throttle opening, a variable oil pressure called modulator pressure is used.

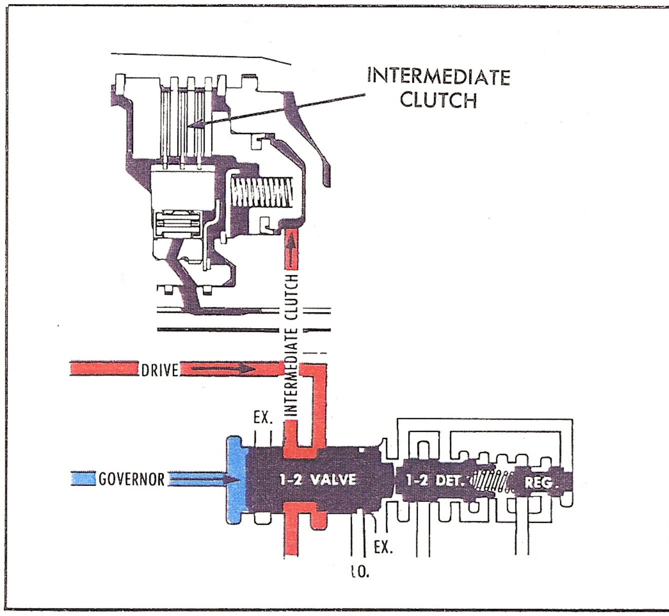


Fig. 31 1-2 Shift

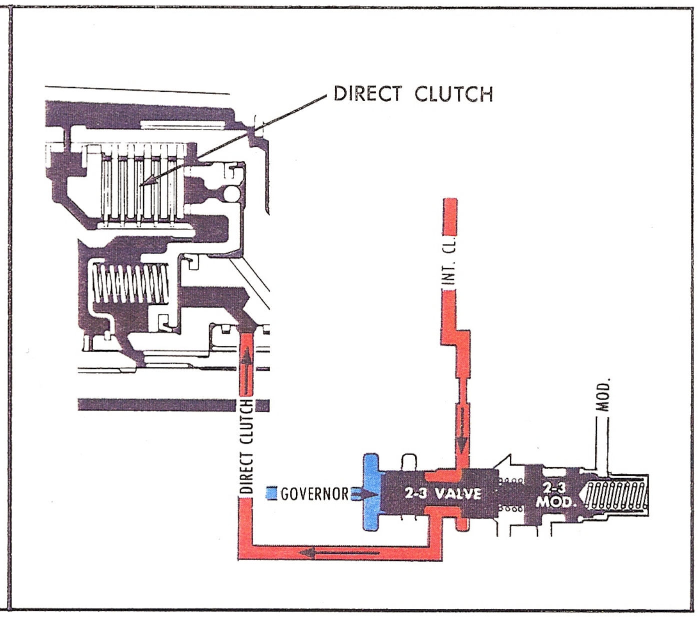


Fig. 32 2-3 Shift

The shift to third gear is initiated by the 2-3 shift valve train. (Fig. 32) The operation of the 2-3 shift valve train is very similar to the 1-2 shift valve train. Springs acting on the valve train tend to keep the shift valve closed while governor pressure attempts to open the valve train. When car speed and governor pressure become great enough to open the 2-3 shift valve train, intermediate clutch oil passes through the shift valve and enters the direct clutch passages to apply the direct clutch, thus shifting the transmission into third gear. Oil pressure to the direct clutch piston is applied only to the small inner area in third gear.

When the accelerator is released and the vehicle

Modulator pressure is regulated by engine vacuum which is an indicator of engine torque and carburetor opening. (Fig. 33) The engine vacuum signal is provided by the vacuum modulator which consists of an evacuated metal bellows, a diaphragm, and springs. These are so arranged that when installed, the bellows and one spring apply a force that acts on the modulator valve to increase modulator pressure. Engine vacuum and the other spring act in the opposite direction to decrease modulator pressure; the result is low engine vacuum (high torque signal) equals high modulator pressure; high engine vacuum (low torque signal) equals low modulator pressure.

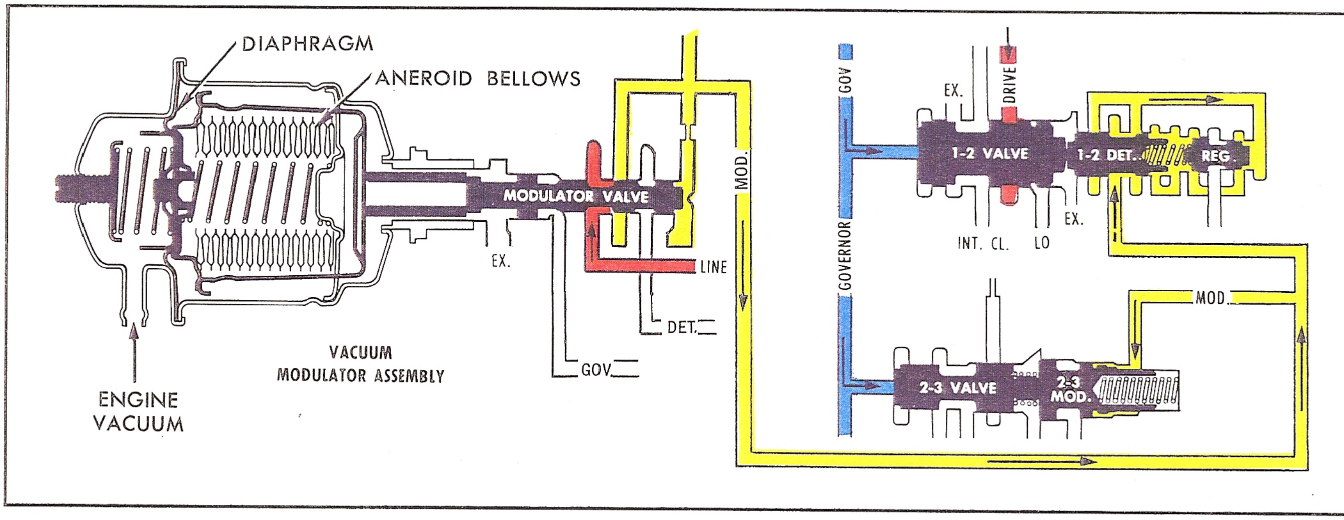



Fig. 33 Modulator Pressure

Modulator pressure is directed to the 1-2 regulator valve which regulates modulator pressure to a lesser pressure that is proportional to modulator pressure. This tends to keep the 1-2 shift valve in the closed or downshift position. Modulator pressure is also directed to the 2-3 modulator valve to apply a variable force proportional to modulator pressure. This tends to hold the 2-3 shift valve in the closed or downshift position. The shifts can now be delayed to take place at higher vehicle speeds with heavy throttle operation.

Line pressure is controlled in Drive range so that it will vary with torque input to the transmission. Since torque input is a product of engine torque and converter ratio, modulator pressure is directed to a pressure regulator boost valve to adjust the line pressure for changes in either engine torque or converter ratio. (Fig. 34)

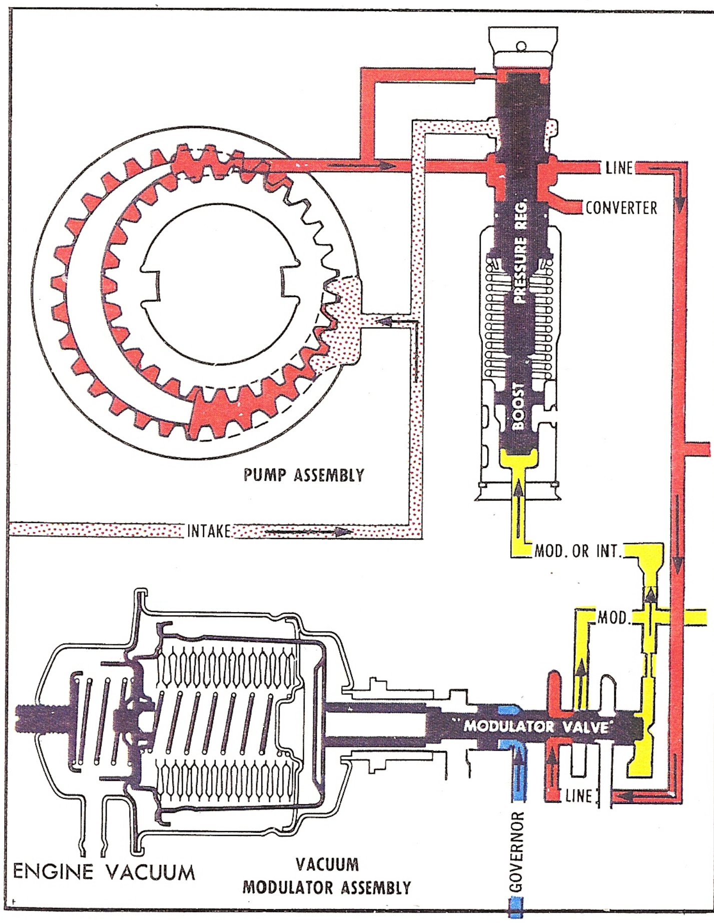



Fig. 34 Line Pressure Control

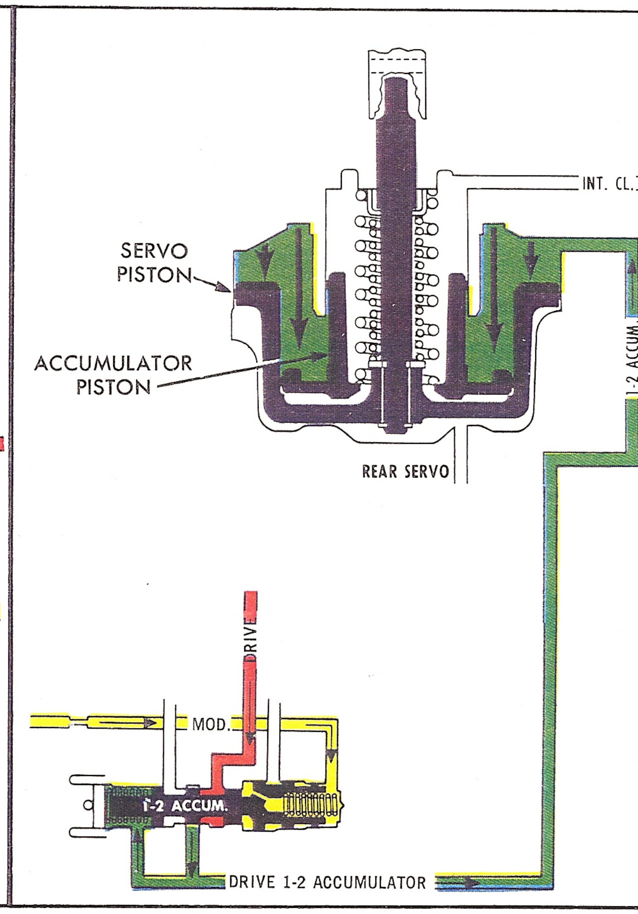



Fig. 35 Rear Servo First Gear

To regulate modulator pressure and, in turn, line pressure with the converter torque ratio that decreases as vehicle speed increases, governor pressure is directed to the modulator valve to reduce modulator pressure with increases in vehicle speed. In this way, line pressure is regulated to vary with torque input to the transmission for smooth shifts with sufficient capacity for both heavy and light acceleration.

The 1-2 shift feel and the durability of the intermediate clutch are dependent on the apply pressure that locks the clutch pack. At minimum or light throttle operation, the engine develops a small amount of torque and as a result the clutch requires less apply pressure to engage or lock. At heavy throttle, the engine develops a great amount of torque which requires a higher apply pressure to lock the clutch pack. If the clutch locks too quickly, the shift will be too aggressive. If it locks too slowly, it will slip excessively and burn due to the heat created by the slippage.

Controlling intermediate clutch apply pressure according to throttle opening is accomplished in two ways. (Fig. 35) First, line pressure is varied by the modulator. Second, a 1-2 accumulator valve train provides a variable accumulator pressure to cushion the clutch apply. The 1-2 accumulator valve system is supplied by drive oil and is controlled by modulator pressure. For light throttle operation, drive oil is re-regulated to a low accumulator pressure. At heavy throttle, accumulator pressure approaches full line pressure. Accumulator or trim pressure as it is known, is supplied to act on one side of the rear accumulator piston located in the rear servo. In first gear the accumulator piston is stroked to its lower position to make it ready for the shift to second gear.

When the 1-2 shift valve opens, intermediate clutch apply oil is also directed to the rear servo accumulator piston stroking the piston against the 1-2 accumulator oil and the accumulator spring. (Fig. 36) This action absorbs some intermediate clutch apply oil and permits the clutch apply time and pressure to be controlled for proper shift feel.

The direct clutch apply rate is controlled by the front accumulator piston. Located in the control valve assembly, it is part of the front accumulator and servo piston system. (Fig. 37) In Drive range second gear, the accumulator is stroked against the accumulator spring by servo oil. Because servo oil is line pressure and varies with throttle opening, the pressure in the accumulator is varied according to throttle.

When the 2-3 shift valve opens, direct clutch oil flows to the direct clutch and front accumulator piston. (Fig. 38) Direct clutch pressure rises so that the force from it, plus the accumulator spring force, overcomes the force from the servo pressure and moves the accumulator piston to the stop on the accumulator piston pin.

This in turn strokes the servo piston the same amount allowing it to just contact the band apply washer on the servo pin. However, it will not move the pin or apply the band.

The stroking of the accumulator piston absorbs some direct clutch oil and permits the direct clutch to apply at a controlled rate for a smooth 2-3 shift.

To take full advantage of the torque converter's ability to multiply torque when required, a 3-2 valve system is used. This valve permits the accelerator to be depressed for moderate acceleration at low speeds in third gear without causing a downshift. This allows the torque converter to sense the changes in engine speed and thus provide additional converter ratio for improved performance.For even more performance with additional throttle opening, the Hydra-matic 400 has a part throttle 3-2 downshift.

A part throttle 3-2 downshift can be accomplished below approximately 33 mph by depressing the accelerator far enough to raise modulator pressure to approximately 90 psi. Modulator pressure and the 3-2 valve spring will move the 3-2 valve against direct clutch oil and allow modulator oil to act on the 2-3 modulator valve. This moves the 2-3 valve train against governor oil and shifts the transmission to second gear. (Fig. 39)

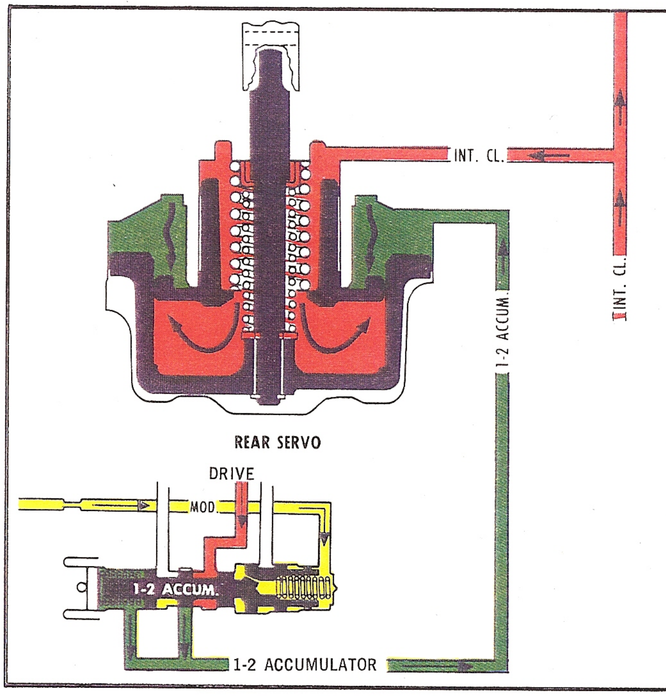



Fig. 36 Rear Servo, Drive Range Second Gear

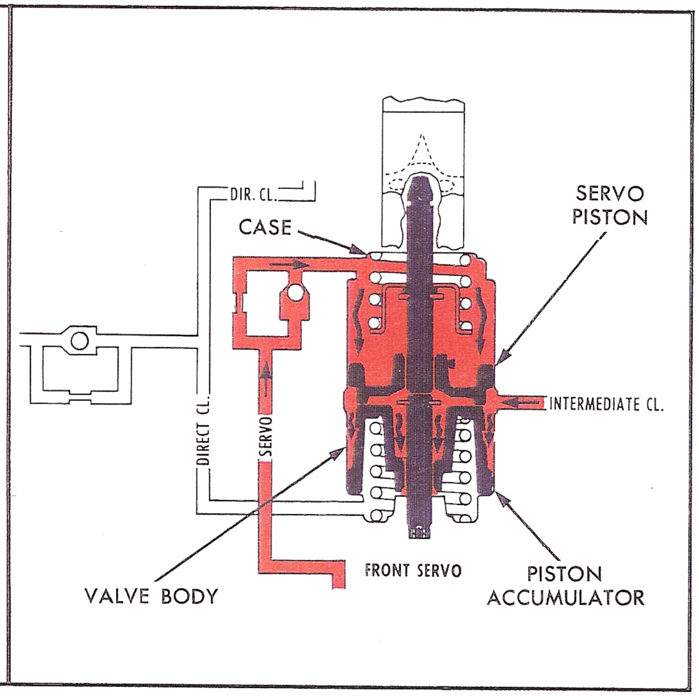



Fig. 37 Front Servo, Drive Range Second Gear

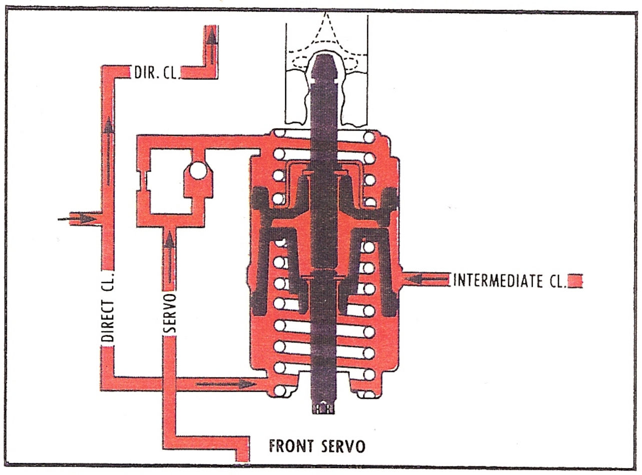
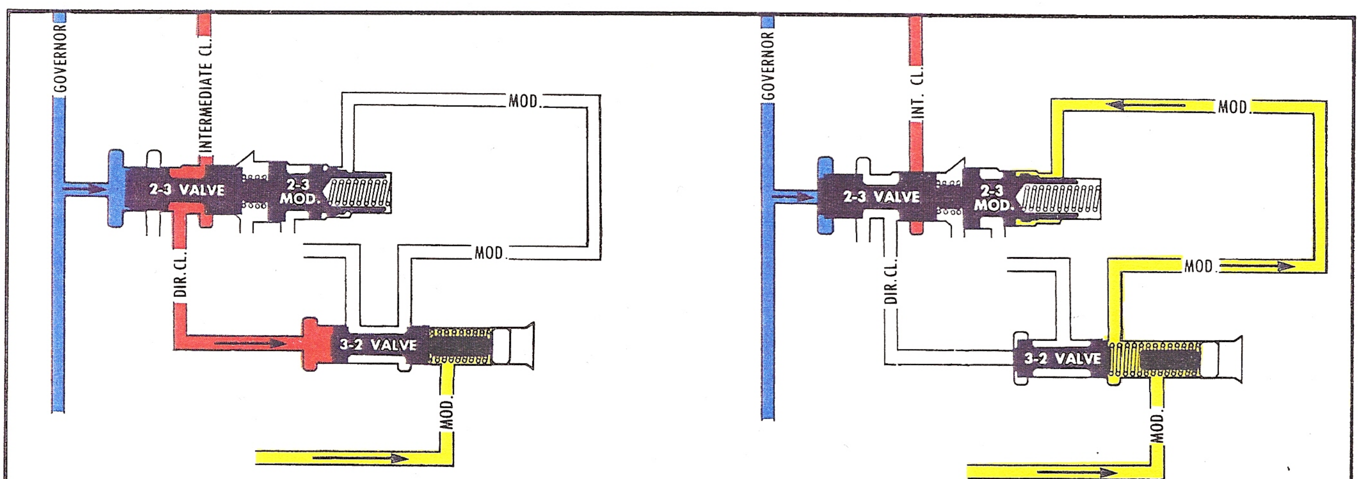



Fig. 38 Front Servo, Drive Range Third Gear




VALVES IN 3RD. GEAR POSITION MODULATOR PRESSURE UNDER APPROX. 90 P.S.I.

PART THROTTLE DOWNSHIFT VALVES IN 2ND. GEAR POSITION MODULATOR PRESSURE OVER 90 P.S.I.

Fig. 39 Part Throttle Downshift 3-2

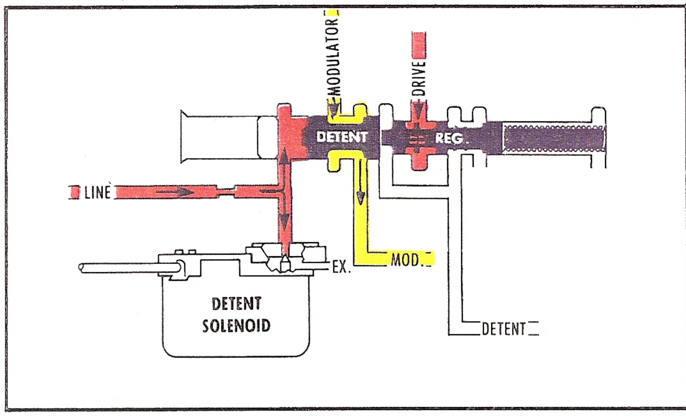



Fig. 40 Detent Valve Closed

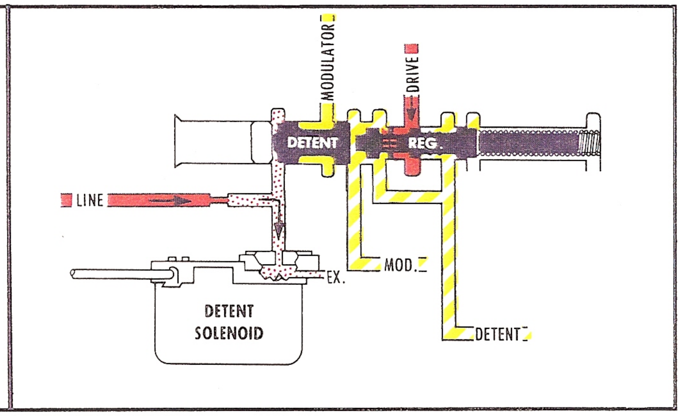



Fig. 41 Detent Valve Open

At speeds below approximately 70 mph, a detent downshift can be obtained by depressing the accelerator.

When the accelerator pedal is fully depressed, the detent valve train replaces the modulator as a controller of shift points.

Line pressure is fed through a small orifice to one end of the detent valve. In normal operation, the cavity at this end of the valve is sealed by the needle valve in the detent solenoid assembly. This line pressure holds the detent valve train in an inoperative or normal position. (Fig. 40)

When the throttle is opened wide, an electric detent switch on the carburetor is closed energizing the detent solenoid. This opens an exhaust at the solenoid causing a pressure drop on the end of the detent valve. The detent regulator valve spring then shifts the detent valve and allows the detent regulator to regulate detent oil to a fixed pressure of approximately 70 psi. (Fig. 41)

When the detent valve shifts, it routes detent pressure into the modulator passages and detent passages to the shift valve trains.

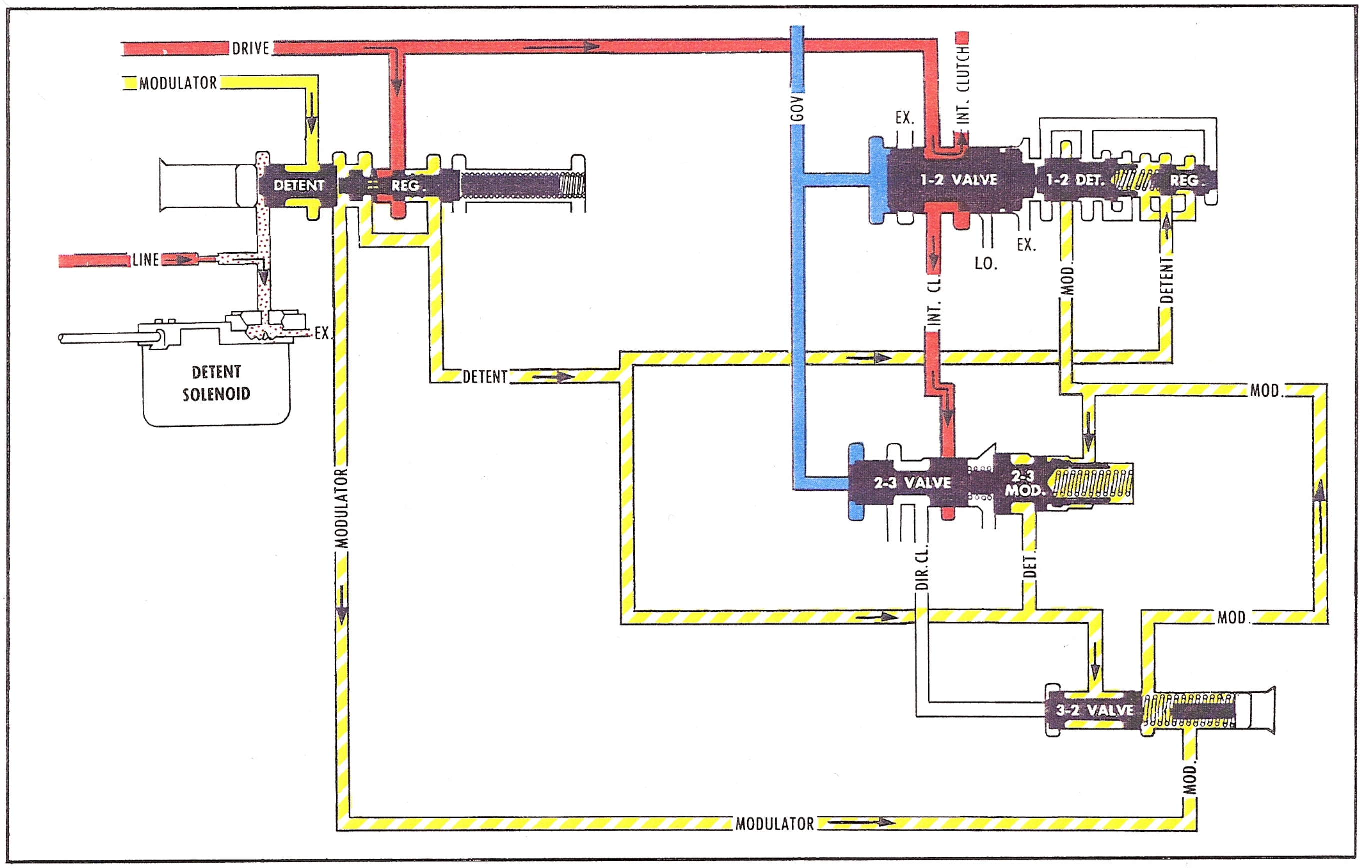



Fig. 42 Detent Downshift - Valves in Second Gear Position

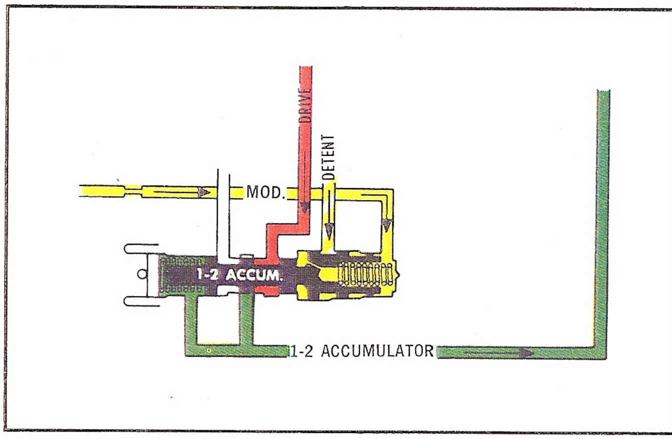



Fig. 43 1-2 Accumulator Valve

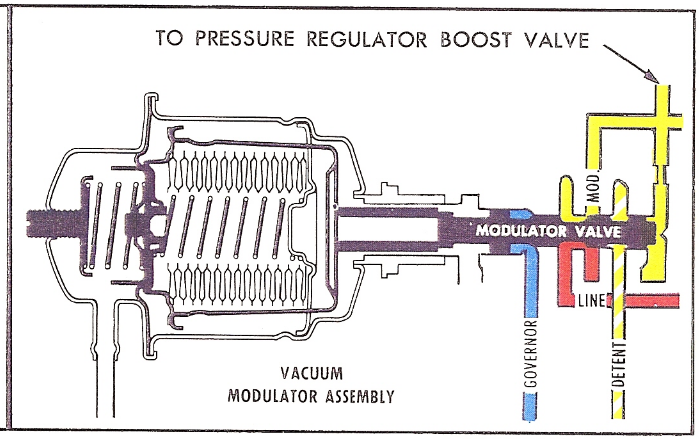



Fig. 44 Modulator Valve During Detent

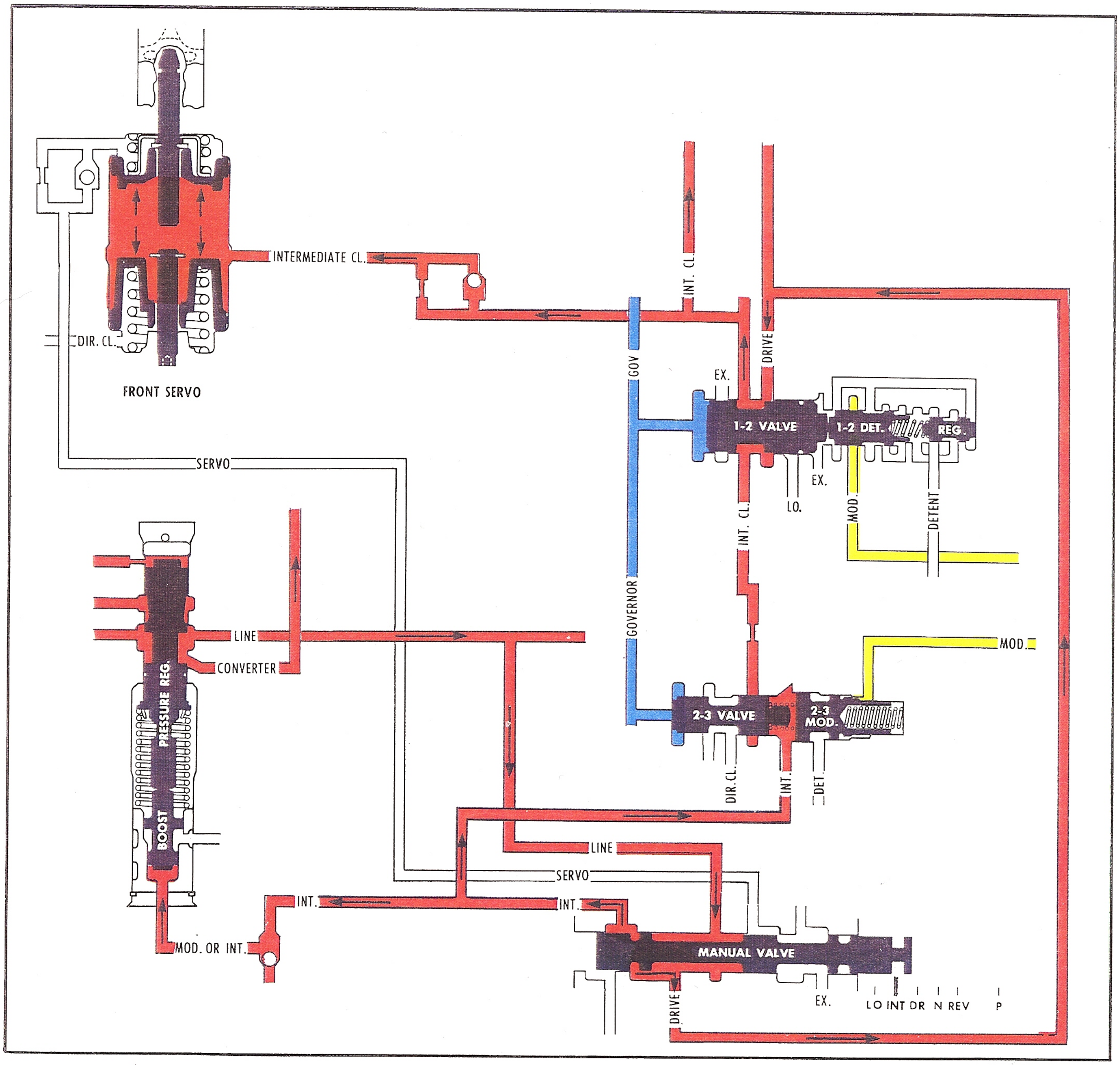



Fig. 45 Valves - Intermediate Range Second Gear

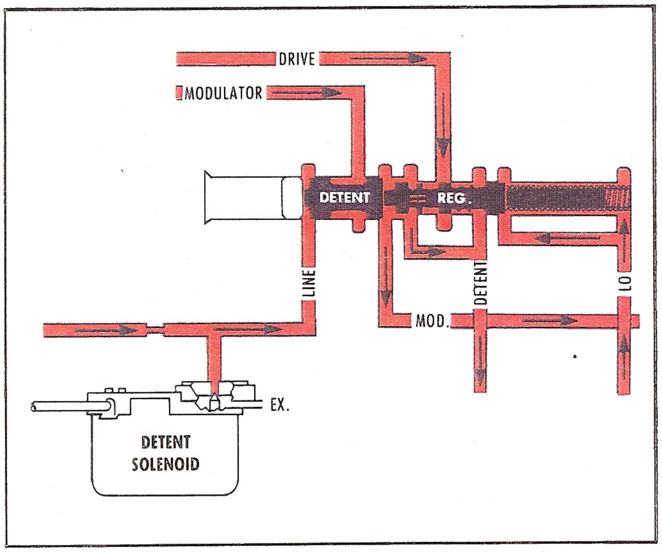



Fig. 46 Lo Range Pressure

Detent oil in the modulator passage and at the 2-3 modulator valve will close the 2-3 shift valve, shifting the transmission to second gear. The upshift points are then controlled by detent pressure in the modulator passages and the detent downshifts by detent pressure in the detent passages.

These shift points are fixed at relatively high speeds by the constant pressure. (Fig. 42)

A detent 2-1 downshift can also be accomplished below approximately 20 mph because detent oil is directed to the 1-2 regulator valve. This allows detent oil to act on the 1-2 regulator and 1-2 detent valve to close the 1-2 shift valve, shifting the transmission to first gear.

To insure clutch durability during 1-2 upshifts under full throttle conditions, detent oil is directed to the 1-2 accumulator valve to increase 1-2 accumulator pressure. (Fig. 43)

Detent oil is also directed to the modulator valve to prevent modulator pressure from dropping below 70 psi. This prevents line pressure from dropping below approximately 105 psi regardless of altitude or vehicle speed. (Fig. 44)

When the selector lever is moved to the Intermediate range position, the manual valve is moved to uncover a passage for Intermediate range oil. (Fig. 45)

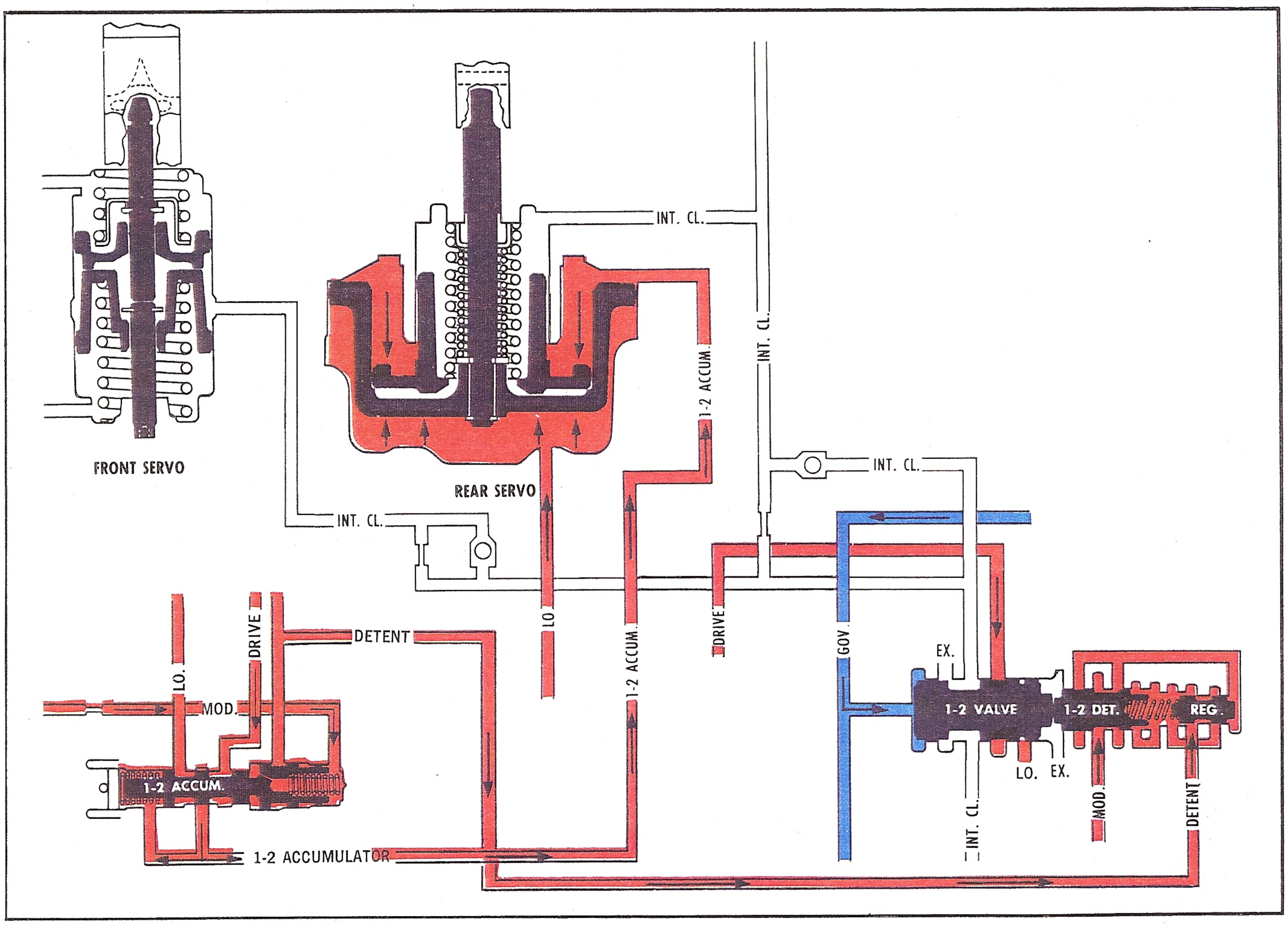



Fig. 47 Lo Range First Gear - Rear Band Applied

The Intermediate range oil is then directed to the 2-3 shift valve and will downshift the transmission from third gear to second gear regardless of vehicle speed.

To provide over-run engine braking, the front band is applied by the front servo. Intermediate clutch oil passes through an orifice to the apply side of the servo piston for a smooth apply of the band. Intermediate range oil pressure is directed to a check ball. This allows it to enter the same passage to the pressure regulator boost valve that the modulator occupied in Drive range. The force of Intermediate range oil on the boost valve raises line pressure to 150 psi to provide sufficient holding forces for over-run engine braking.

Moving the selector lever to Lo range positions the manual valve to open a passage directing Lo range oil to the detent regulator valve and spacer pin. The spring then moves the detent and regulator valves to the opposite end of the valve bore. (Fig. 46)

Lo range oil in these two areas prevents the detent valve from regulating. Drive oil passes through the detent regulator valve into the detent and modulator passages at a Lo range pressure of 150 psi. This increase in detent and modulator pressures will downshift the 1-2 shift valve at speeds below approximately 40 mph and will prevent the transmission from upshifting out of first gear regardless of vehicle speed.

When the 1-2 shift valve closes, the exhausting intermediate clutch oil lifts two ball checks off their seats for a fast intermediate clutch and front band release. (Fig. 47)

To provide over-run engine braking, the rear band is applied by directing Lo range oil pressure to the rear servo.

Lo range oil is directed to the 1-2 accumulator valve during Lo range operation to raise 1-2 accumulator pressure to line pressure. This increased pressure directed to the rear servo

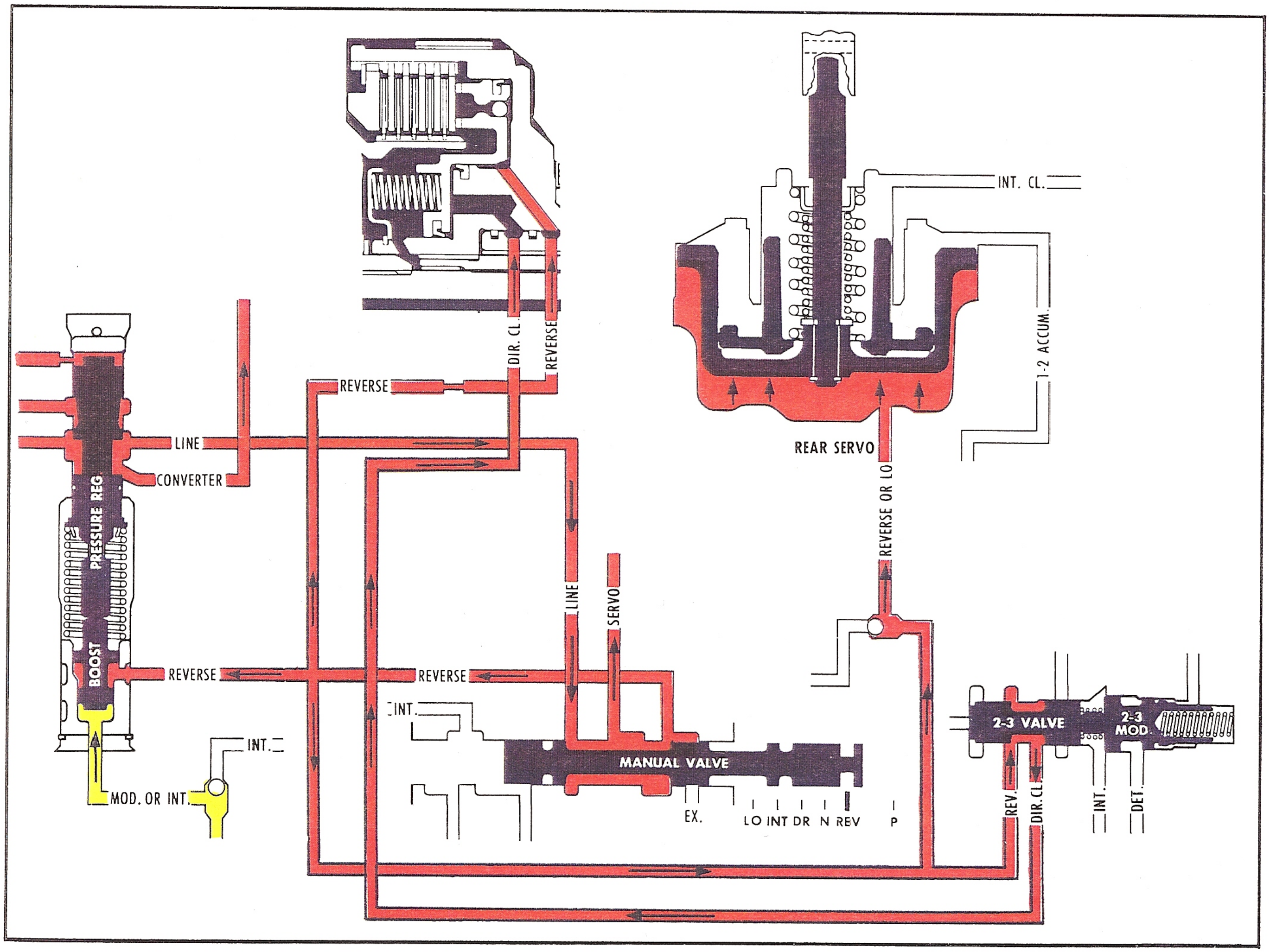



Fig. 48 Reverse - Rear Band Applied

accumulator piston resists servo apply pressure and slows down the apply of the rear band for a smooth manual shift to Lo range first gear or for a 2-1 shift in Lo range.

Selecting the Reverse position moves the manual valve to allow Drive, Intermediate, and Lo range oil to be exhausted and allows line pressure to enter the reverse passages. (Fig. 48) Reverse oil pressure is directed from the manual valve to the large outer area of the direct clutch piston and to the 2-3 shift valve where it enters the direct clutch exhaust port and passes through the downshifted 2-3 shift valve to enter the third gear direct clutch apply passage. This directs reverse oil pressure to the small inner area of the direct clutch piston. Reverse oil pressure directed to the apply areas of the direct clutch piston apply the clutch. Reverse oil pressure is directed to a check ball that allows it to enter the same passage to the rear servo apply piston that Lo range oil pressure occupied in Lo range. This applies the rear band. To insure adequate oil pressure for the torque requirements in reverse, reverse oil pressure is directed to the pressure boost valve which increase line pressure to a maximum of approximately 260 psi.

# FRONT SERVO OPERATION

## DRIVE RANGE—FIRST GEAR

Servo oil from the manual valve in Drive range charges the accumulator by stroking the servo and accumulator pistons against the accumulator spring. (Fig. 49) This prepares the accumulator for the controlled apply of the direct clutch on a 2-3 shift. The charging of the accumulator in Drive range, first gear, also makes it possible to have a controlled 1-3 let-up shift as the accumulator is prepared in first gear for direct clutch apply.

Servo oil and the servo release spring prevents the apply of the band in second gear Drive range when intermediate clutch apply oil is directed between the servo and accumulator pistons.

Servo oil is also present in Reverse and Neutral ranges.

## DRIVE RANGE—SECOND GEAR

Servo oil charging the accumulator is present in first and second gears and has the servo and accumulator pistons stroked down against the accumulator spring. (Fig. 50) In second gear, intermediate clutch oil is directed between the servo and accumulator pistons but does not separate the pistons. This is because the force of servo oil holding the piston down is equal to the force of intermediate clutch oil attempting to stroke the servo piston up.

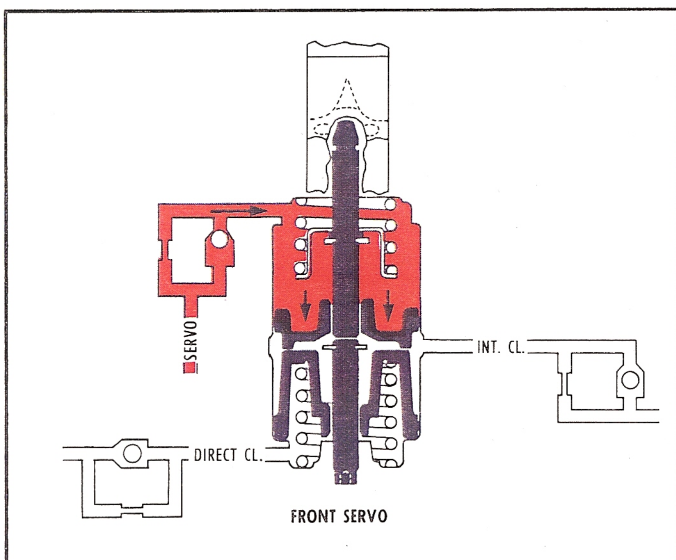



Fig. 49 Neutral or Drive Range - First Gear

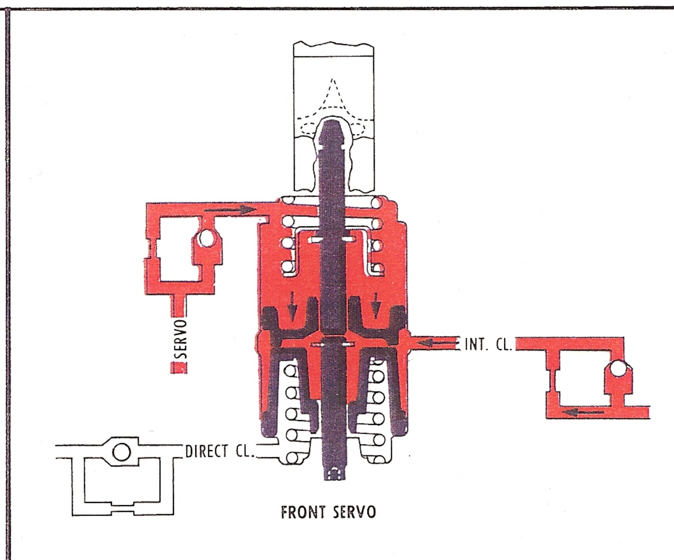



Fig. 50 Drive Range - Second Gear

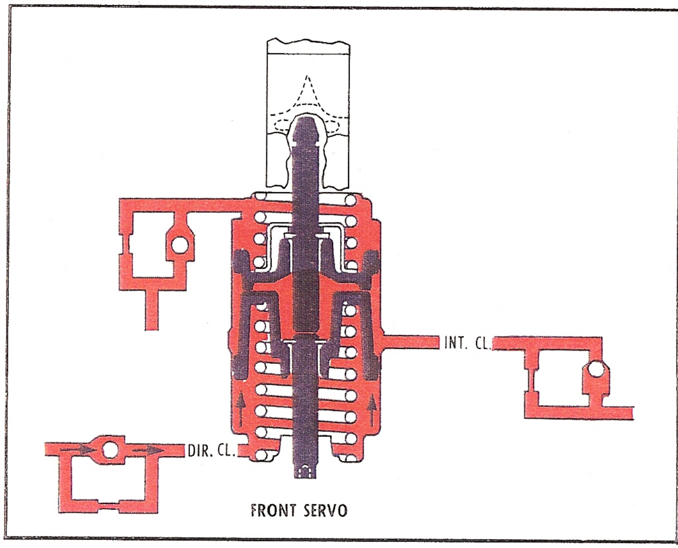



Fig. 51 Drive Range - Third Gear

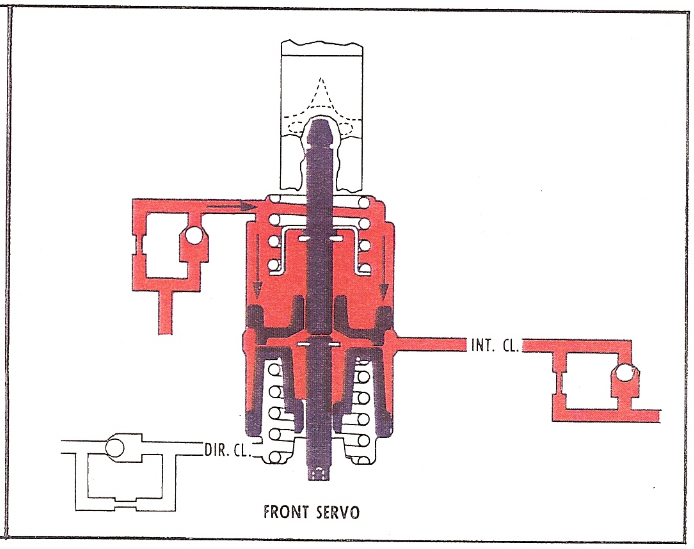



Fig. 52 Drive Range - 3-2

## DRIVE RANGE—THIRD GEAR

When the direct clutch is applied, clutch pressure rises to its force plus the accumulator spring force. (Fig. 51) This overcomes the force from the servo pressure and moves the accumulator piston to the stop on the accumulator piston pin. This in turn, strokes the servo piston the same amount of travel allowing it to just contact the washer on the servo pin. However, it will not move the servo pin to apply the band.

The stroking of the accumulator piston absorbs some direct clutch oil and permits the direct clutch to apply at a controlled rate for a smooth 2-3 shift.

## DRIVE RANGE—3-2

The release of the direct clutch is controlled by the front servo, two orifices, and two check balls. This allows a smooth transfer of the driving load to the intermediate sprag. The controlled release pressure lets the engine increase its rpm for the lower gear ratio of second gear during detent downshifts. This results in a smooth shift and better acceleration.

Servo oil seats a check ball, and oil must pass through the orifice which slows the stroking of the servo and accumulator pistons. The exhausting oil from the accumulator and the direct clutch seats a second check ball. The exhausting direct clutch oil passes through an orifice which controls the clutch pressure during the direct clutch release. (Fig. 52)

## INTERMEDIATE RANGE—SECOND GEAR

During a manual 3-2 downshift, intermediate clutch oil from the 1-2 shift valve seats the check ball and passes through an orifice to apply the front band. The pressure applying the band is also controlled by the stroking of the accumulator piston which is resisted by the accumulator spring and the slow orificed exhaust of direct clutch oil. (Fig. 53)

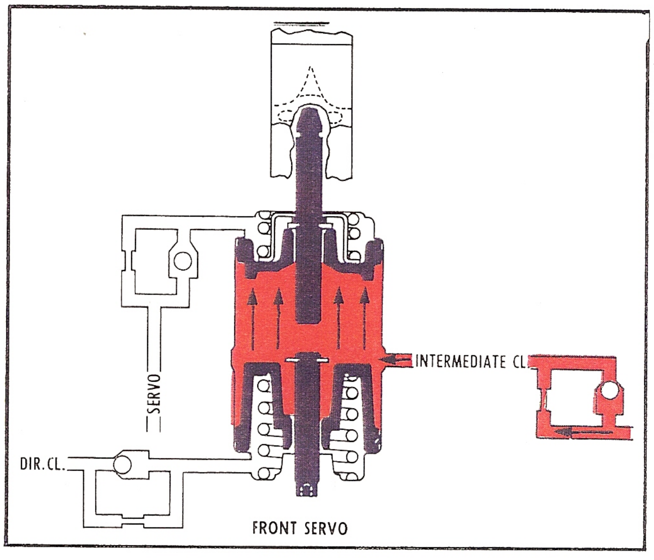



Fig. 53 Intermediate Range Second Gear

# REAR SERVO AND ACCUMULATOR OPERATION

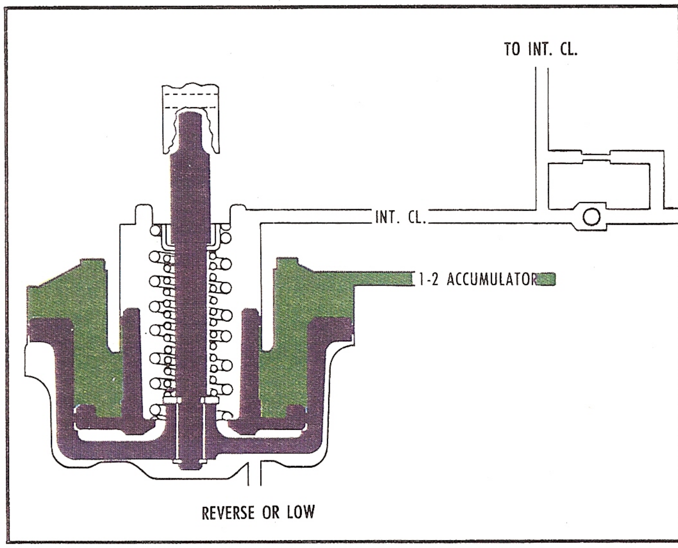



Fig. 54 Drive and Intermediate - First Gear

## DRIVE—INTERMEDIATE—FIRST GEAR

In first gear, Drive and Intermediate ranges, 1-2 accumulator oil is directed to the rear servo accumulator piston in preparation for the 1-2 shift. (Fig. 54)

## DRIVE—INTERMEDIATE—SECOND GEAR

Intermediate clutch apply oil is directed to the rear servo accumulator piston stroking the piston against 1-2 accumulator oil and the accumulator spring. (Fig. 55) This action absorbs some intermediate clutch apply oil and permits the intermediate clutch to apply at reduced pressure for a smooth 1-2 shift.

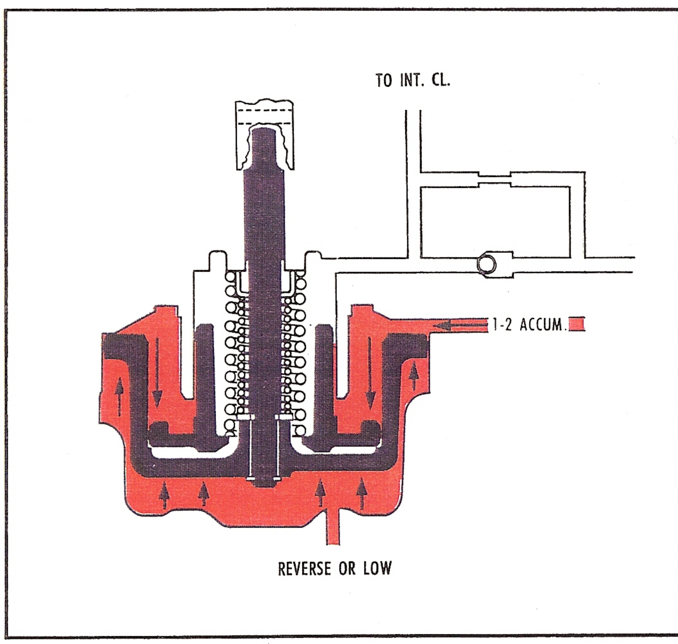



Fig. 56 Lo Range - First Gear

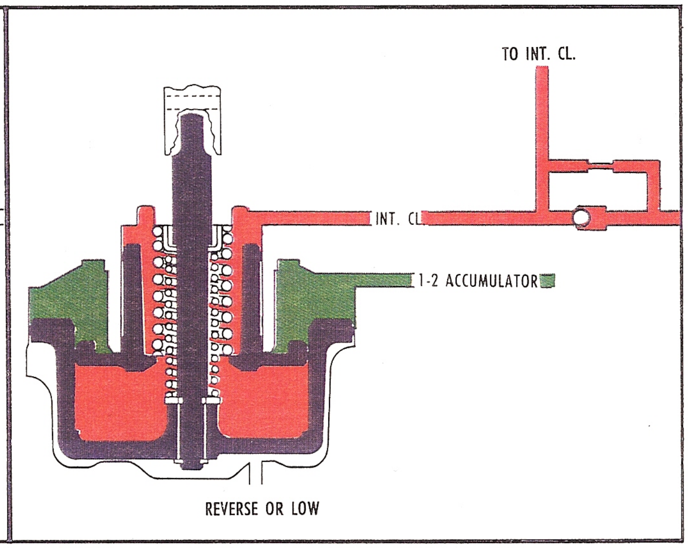



Fig. 55 Drive and Intermediate - Second Gear

## LO RANGE—FIRST GEAR

Over-run engine braking in Lo range first gear is provided by the rear servo applying the band to hold the reaction carrier from clockwise rotation. (Fig. 56)

The 1-2 accumulator oil is directed to the accumulator piston which attempts to prevent the servo from applying. Lo range oil directed to the servo piston which has the larger area, applies the band. Because 1-2 accumulator oil is present, the force applying the band is lowered. This provides a smooth apply.

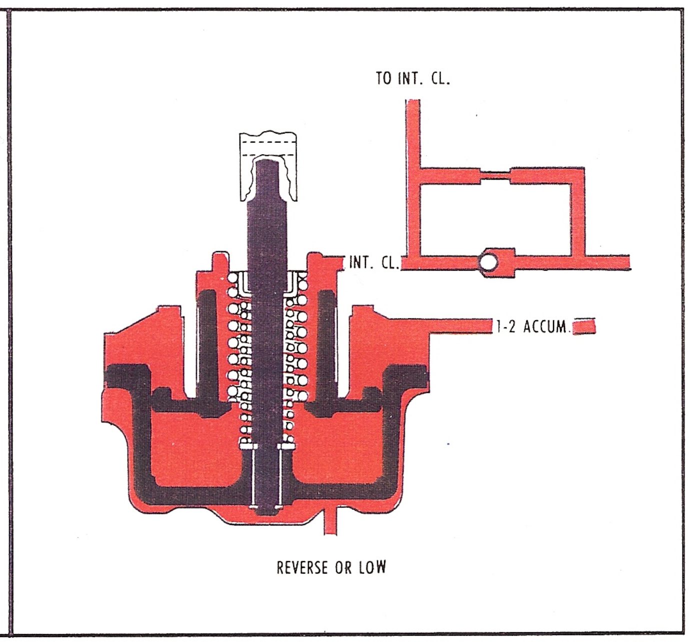



Fig. 57 Lo Range - Second Gear

## LO RANGE—SECOND GEAR

In second gear the rear band is released. Intermediate clutch oil is directed to the release side of the servo piston which, with line oil in the 1-2 accumulator oil passage, balances out the Lo range oil on the apply side of the servo piston. (Fig. 57) The servo release spring strokes the servo piston to the released position.

## REVERSE

In reverse, the rear band is applied to hold the reaction carrier. (Fig. 58) Reverse oil is directed to the servo piston to apply the band. To insure that the band will hold the reaction carrier for the reverse gear ratio, line pressure is increased. No other oil pressures are present in the servo to resist the apply of the servo piston.

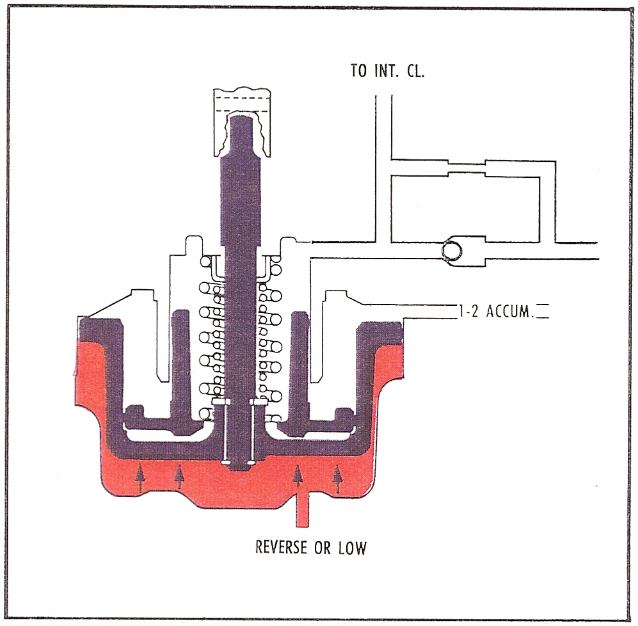
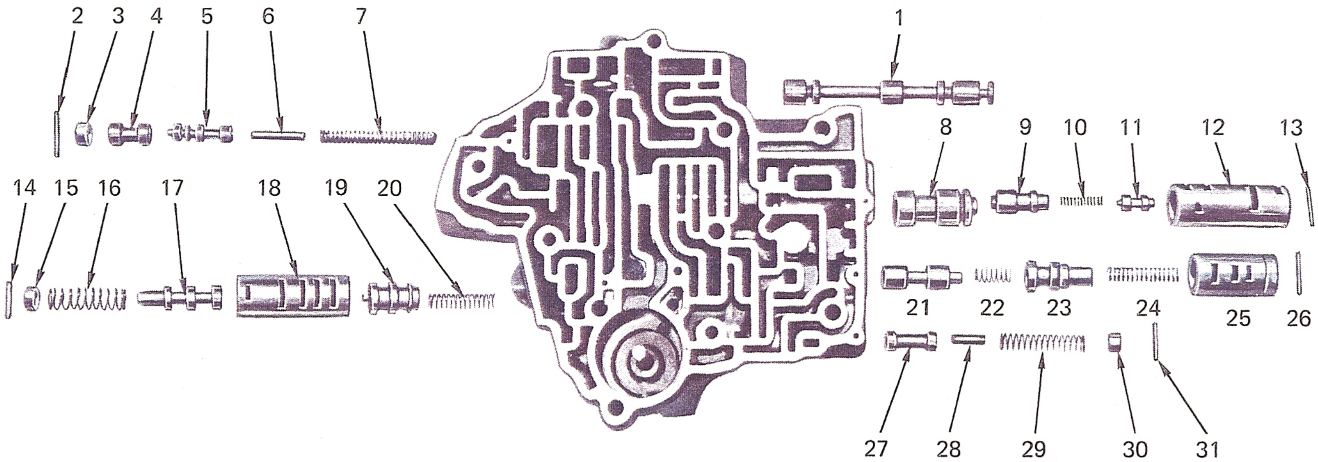



Fig. 58 Reverse

# NOTES

# TYPICAL THM 400 VALVE BODY ASSEMBLY




1. Manual Valve
2. Retaining Pin
3. Bore Plug
4. Detent Valve
5. Detent Regulator Valve
6. Spacer Pin
7. Detent Regulator Spring
8. 1-2 Shift Valve
9. 1-2 Detent Valve
10. 1-2 Regulator Spring
11. 1-2 Regulator Valve
12. 1-2 Modulator Bushing
13. Retaining Pin
14. Grooved Retaining Pin
15. Bore Plug
16. 1-2 Accumulator Secondary Spring
17. 1-2 Accumulator Secondary Valve
18. 1-2 Accumulator Bushing
19. 1-2 Primary Accumulator Valve
20. 1-2 Accumulator Primary Spring
21. 2-3 Shift Valve
22. 3-2 Intermediate Spring
23. 2-3 Modulator Valve
24. 2-3 Valve Spring
25. 2-3 Modulator Bushing
26. Retaining Pin
27. 3-2 Valve
28. Spacer Pin
29. 3-2 Valve Spring
30. Bore Plug
31. Retaining Pin

# COMPLETE HYDRAULIC OIL CIRCUITS

# NEUTRAL—ENGINE RUNNING

| | | |
|---|---|---|
| Forward Clutch - Released | Direct Clutch - Released | Intermediate Clutch - Released |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Ineffective |
| | Rear Band - Released | |

Whenever the engine is running at idle with the selector lever in N, oil from the pump is directed as shown in Fig. 59.

1. Pressure Regulator Valve
2. Converter
   a. Oil Cooler
   b. Lubrication System
3. Manual Valve
4. Detent Valve
5. Detent Solenoid
6. Vacuum Modulator Valve
7. Front Servo

Cooling and Lubrication

Oil flows from the pump to the pressure regulator valve which regulates the pump pressure. When the pump output exceeds the demand of line pressure, oil from the pressure regulator valve is directed to the converter feed passage to fill the converter. Converter return oil is directed to the transmission cooler. Oil from the cooler is directed to the transmission lubrication system.

Line pressure acts on the:

1. Manual Valve
2. Detent Valve
3. Detent Solenoid
4. Modulator Valve
5. Front Servo

Line pressure at the modulator valve is re-regulated to modulator oil which acts on the pressure boost valve, 1-2 accumulator, and primary valves. It then passes through the detent valve and 3-2 valve to the 1-2 and 2-3 valve trains.

SUMMARY

The converter is filled, and all clutches and bands are released. The transmission is in Neutral.

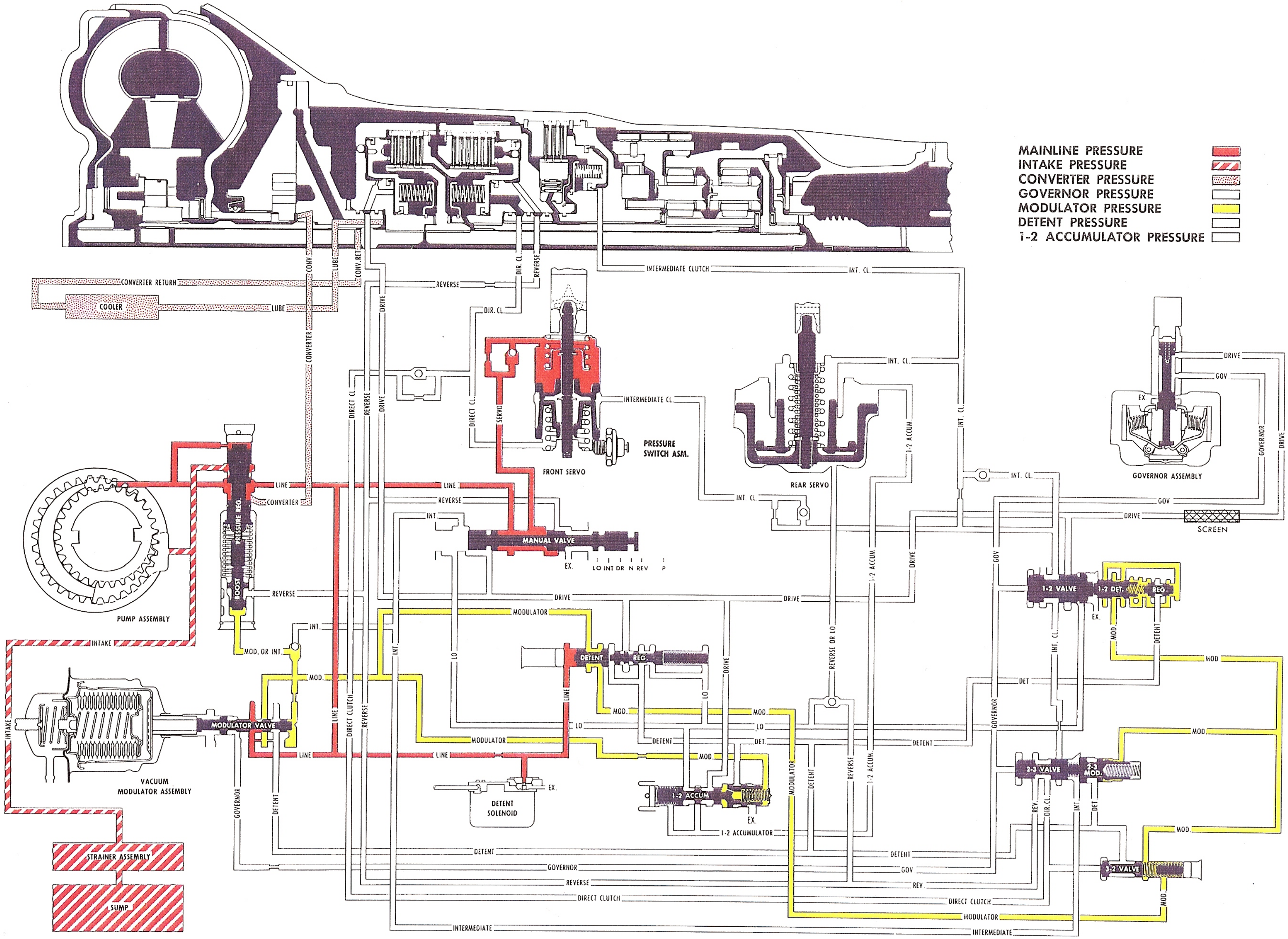



Fig. 59 Neutral Engine Running

## DRIVE RANGE—FIRST GEAR

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Released | Intermediate Clutch - Released |
| Lo Roller Clutch - Effective | Front Band - Released | Intermediate Sprag - Ineffective |
| | Rear Band - Released | |

When the selector lever is moved to the Drive position, the manual valve is repositioned to allow line pressure to enter the drive circuit. Drive oil then flows as shown in Fig. 60.

1. Forward Clutch
2. 1-2 Shift Valve
3. Governor Assembly
4. 1-2 Accumulator Valve
5. Detent Regulator Valve

Basic Control

Drive oil is directed to the forward clutch where it acts on two areas of the clutch piston to apply the forward clutch. The inner area is fed through an unrestricted passage. The outer area is fed through an orifice to insure a smooth shift from Park, Neutral, and Reverse to Drive.

Drive oil at the governor assembly is regulated to a variable pressure called governor pressure. Governor pressure increases with vehicle speed and acts against the ends of the 1-2, 2-3 shift valves, and the modulator valve.

Drive oil is also regulated to another variable pressure at the 1-2 accumulator valve. This pressure, called 1-2 accumulator pressure, is controlled by modulator pressure and is directed to the rear servo. The 1-2 accumulator oil at the rear servo acts on the accumulator piston.

SUMMARY

The converter is filled. The forward clutch is applied. The transmission is in Drive Range - first gear.

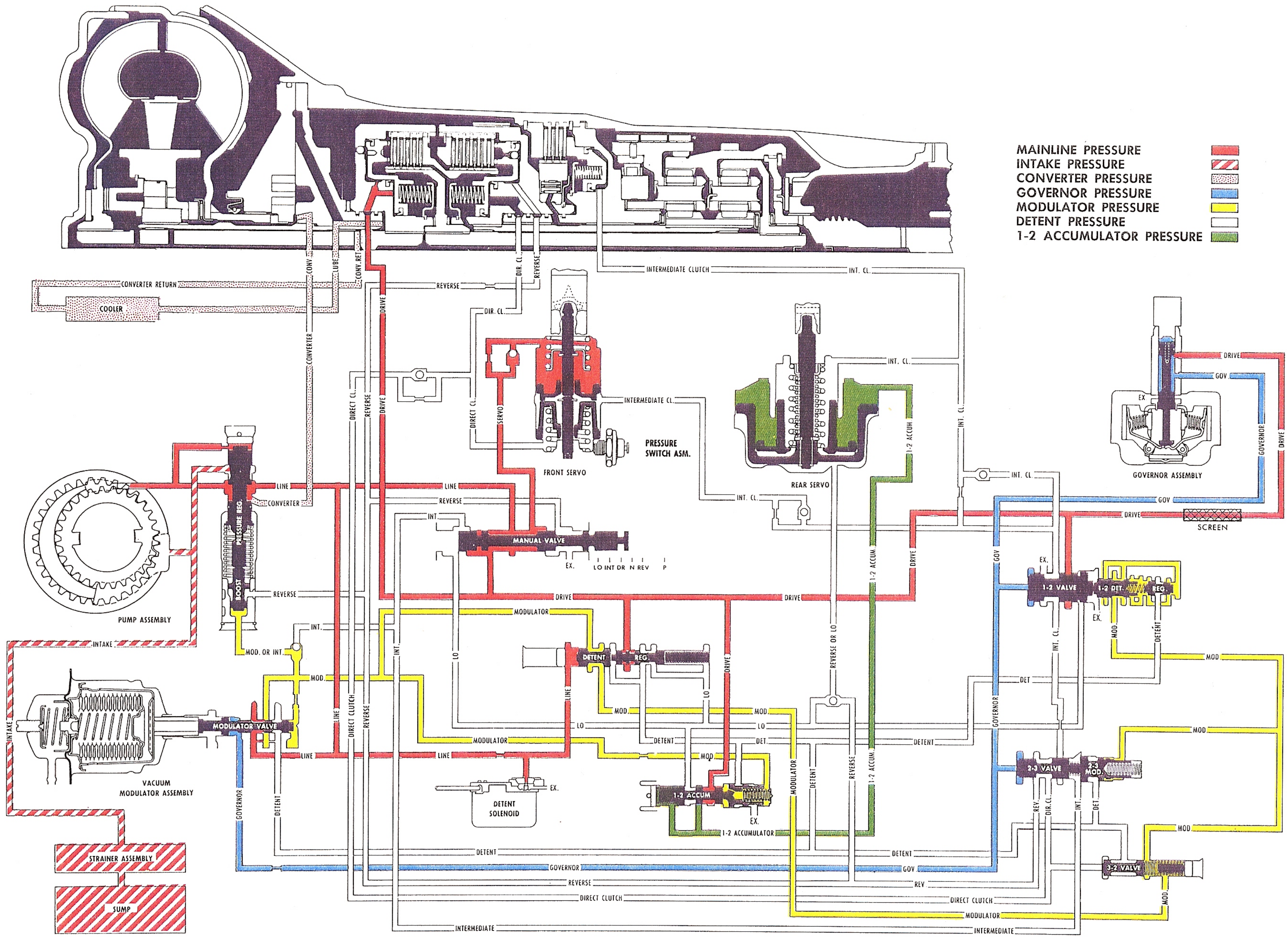



Fig. 60 Drive Range - First Gear

## DRIVE RANGE—SECOND GEAR

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Released | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Effective |
| | Rear Band - Released | |

As both vehicle speed and governor pressure increase, the force of governor oil acting on the 1-2 shift valve will overcome the force of regulated modulator oil pressure. This allows the 1-2 shift valve to open, permitting drive oil to enter the intermediate clutch passage. Oil in this passage is called intermediate clutch oil.

Intermediate clutch oil from the 1-2 shift valve is directed as shown in Fig. 61

1. Intermediate Clutch
2. Rear Servo
3. Front Servo and Accumulator Pistons
4. 2-3 Shift Valve

Basic Control

Intermediate clutch oil from the 1-2 shift valve seats a one-way check ball and flows through an orifice to the intermediate clutch piston to apply the intermediate clutch. At the same time, intermediate clutch oil moves the accumulator piston against the 1-2 accumulator oil and the accumulator spring to maintain lower pressure in the clutch during a 1-2 shift for a smooth clutch apply. Intermediate clutch oil seats a second one-way check ball and flows to the front servo and accumulator pistons. Intermediate clutch oil is also directed to the 2-3 shift valve.

SUMMARY

The forward and intermediate clutches are applied. The transmission is in Drive Range - second gear.

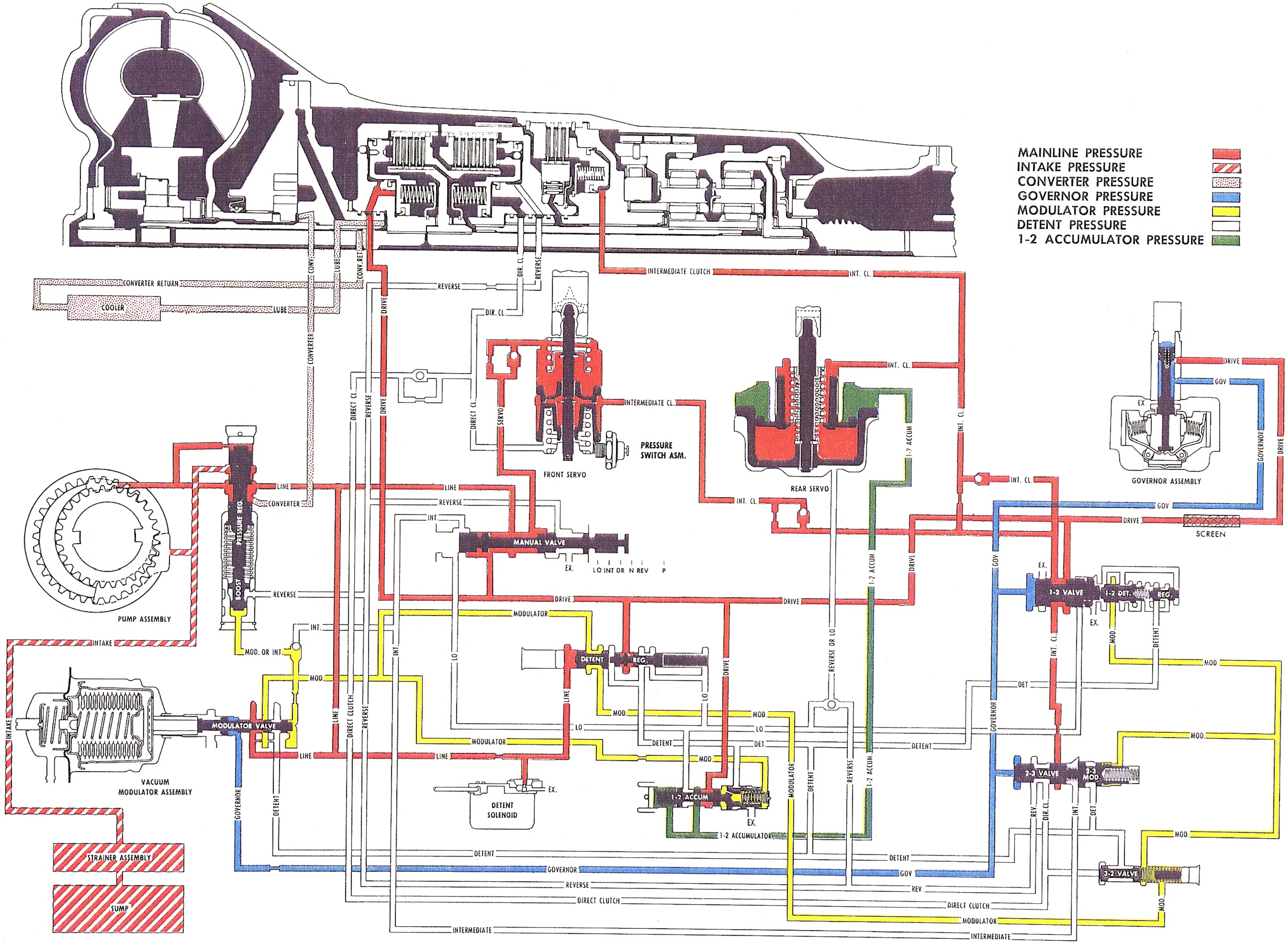



Fig. 61 Drive Range – Second Gear

## DRIVE RANGE—THIRD GEAR

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Applied | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Ineffective |
| | Rear Band - Released | |

As vehicle speed and governor pressure increase, the force of governor oil acting on the 2-3 shift valve overcomes the force of the 2-3 shift valve spring and modulator oil. This allows the 2-3 shift valve to move, feeding intermediate clutch oil to the direct clutch passage. This oil is called direct clutch oil.

Direct clutch oil from the 2-3 shift valve is directed as shown in Fig. 62.

1. Direct Clutch

2. Front Accumulator Piston

3. 3-2 Valve

Basic Control

Direct clutch oil from the 2-3 shift valve flows past a one-way check valve to the inner area of the direct clutch piston to apply the direct clutch. Simultaneously, direct clutch oil is fed to the front accumulator piston. The pressure of the direct clutch oil, combined with the accumulator spring, moves the accumulator and servo pistons against the servo oil. This acts as an accumulator for a smooth direct clutch apply.

Direct clutch oil is also supplied to the 3-2 valve to move the valve against modulator pressure. This cuts off modulator oil to the 1-2 detent and 2-3 modulator valves and allows the transmission to utilize the torque multiplying characteristics of the converter during medium throttle operation without downshifting.

SUMMARY

The forward, intermediate and direct clutches are applied. The transmission is in Drive Range - third gear (direct drive).

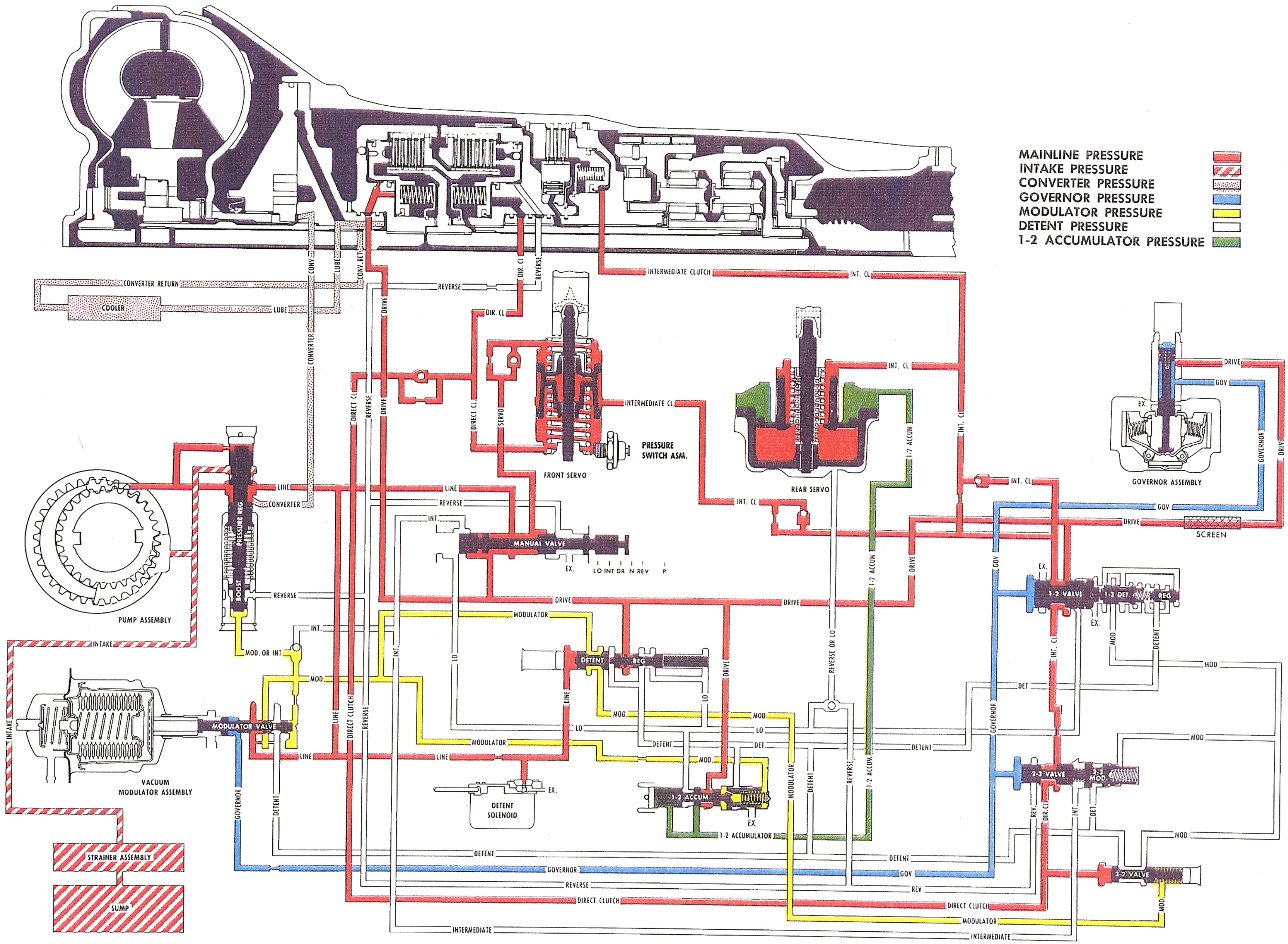



Fig. 62 Drive Range - Third Gear

## PART THROTTLE 3-2 DOWNSHIFTS

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Applied in 3rd | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Effective in 2nd |
| Direct Clutch - Released in 2nd | Rear Band - Released | Intermediate Sprag - Ineffective in 3rd |

A part throttle 3-2 downshift can be accomplished below approximately 33 mph by depressing the accelerator far enough to raise modulator pressure to approximately 90 psi. Modulator pressure and the 3-2 valve spring will move the 3-2 valve against direct clutch oil and allow modulator oil to act on the 2-3 modulator valve. This moves the 2-3 valve train against governor oil and shifts the transmission to second speed as shown in fig. 63.

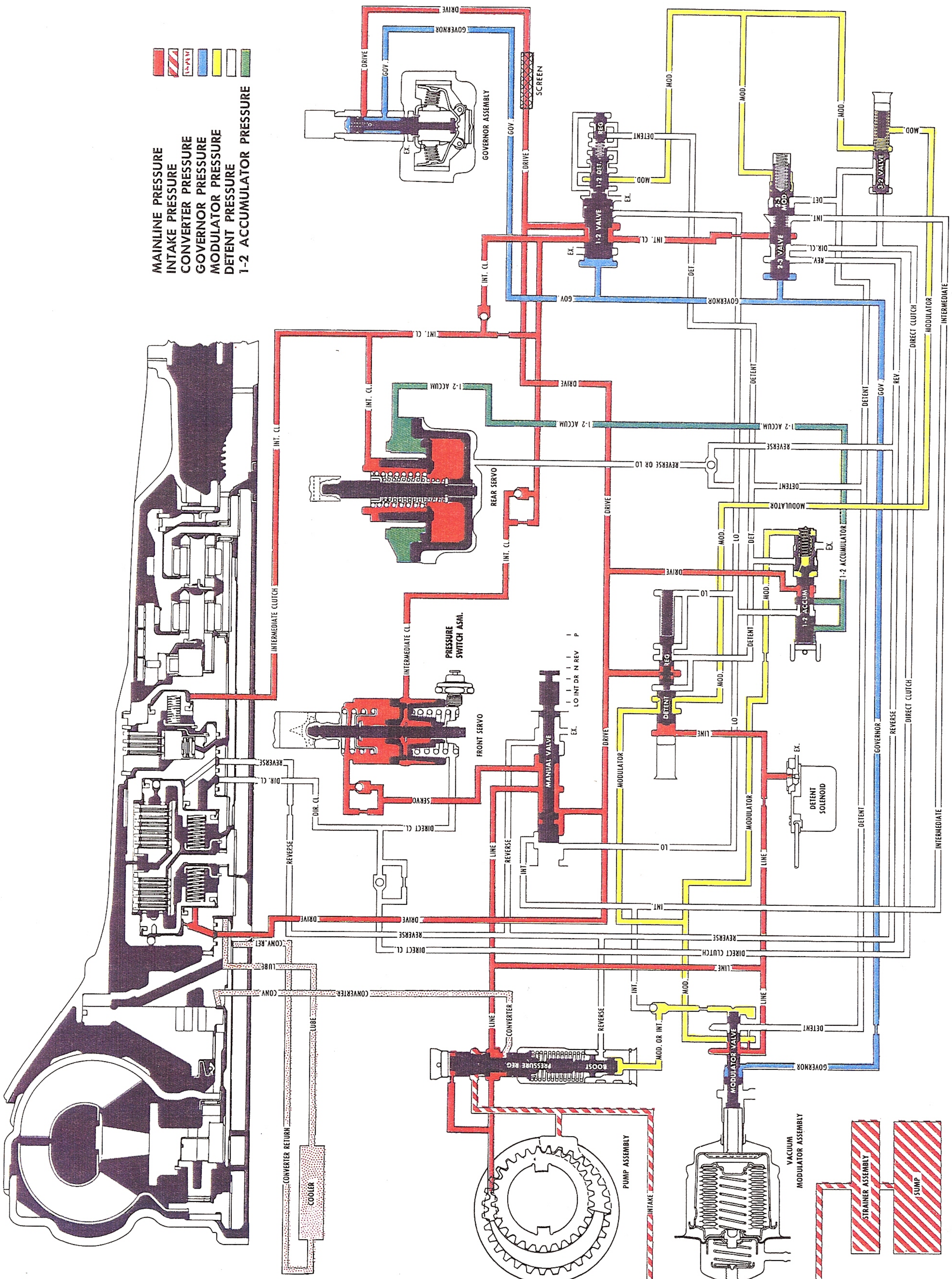



Fig. 63 Part Throttle 3-2 Downshift

# DETENT DOWNSHIFTS
## Valves in Second Gear Position

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Released | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective | Front Band - Released | Intermediate Sprag - Effective |
| | Rear Band - Released | |

While operating at speeds below approximately 70 mph, a forced or detent 3-2 downshift is possible by depressing the accelerator fully. This engages an electrically operated switch at the carburetor and activates the detent solenoid. The detent solenoid opens an orifice that allows line oil at the detent valve to be exhausted, thus permitting the detent regulator valve to operate. Line oil acting on the detent valve and solenoid is supplied by a smaller orifice.

Drive oil on the detent regulator valve is then regulated to detent pressure of approximately 70 psi. Detent oil is then routed as shown in Fig. 64.

1. Modulator Passage
2. 1-2 Regulator Valve
3. 2-3 Modulator Valve
4. 3-2 Valve
5. 1-2 Primary Accumulator Valve
6. Vacuum Modulator Valve

Detent oil in the modulator passage and at the 2-3 modulator valve will close the 2-3 shift valve below approximately 70 mph shifting the transmission to second gear.

A detent 2-1 downshift can also be accomplished below approximately 20 mph because detent oil is directed to the 1-2 regulator valve exhaust port. This allows detent oil to act on the 1-2 regulator and 1-2 detent valve to close the 1-2 shift valve, shifting the transmission to first gear.

To insure clutch durability during 1-2 upshifts under detent conditions, detent oil is directed to the 1-2 accumulator primary valve to increase 1-2 accumulator oil pressure acting on the rear servo accumulator piston.

Detent oil is also directed to the modulator valve to prevent modulator pressure from regulating below 70 psi at high speeds or at high altitudes.

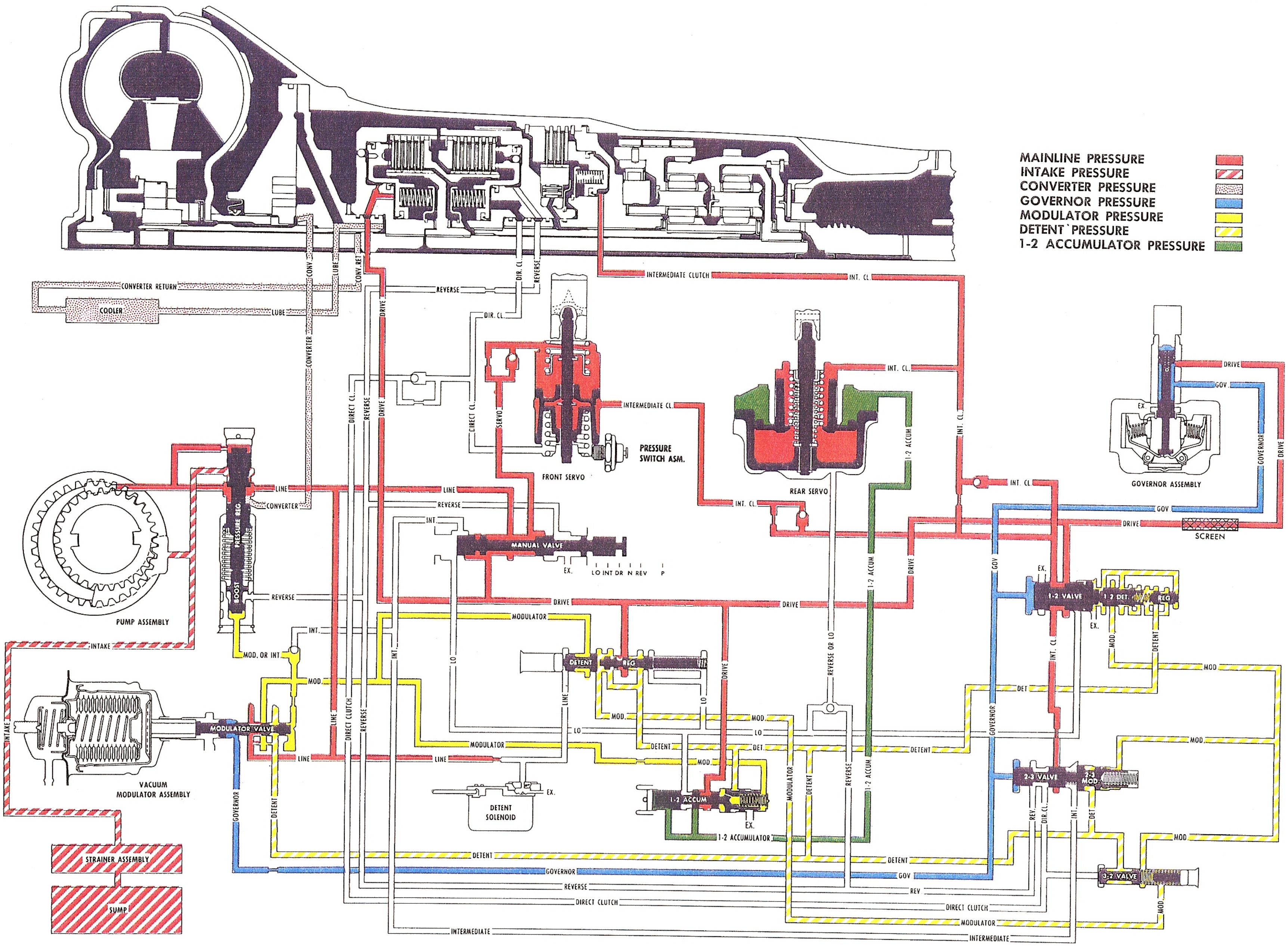



Fig. 64 Detent Downshift Valves in Second Gear Position

# INTERMEDIATE RANGE
## Valves in Second Gear Position

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Released | Intermediate Clutch - Applied |
| Lo Roller Clutch - Ineffective | Front Band - Applied | Intermediate Sprag - Effective |
| | Rear Band - Released | |

A 3-2 downshift can be accomplished by moving the selector lever from Drive to Intermediate range. When the selector lever is in the Intermediate position, intermediate oil from the manual valve is directed as shown in Fig. 65.

1. Pressure Boost Valve

2. 2-3 Shift Valve

Intermediate oil at the boost valve will increase line pressure to 150 psi. This increased intermediate oil pressure at the 2-3 shift valve will close the valve regardless of car speed.

For engine braking, the front band is applied by exhausting servo oil at the manual valve in Intermediate range. This allows intermediate clutch oil, acting on the servo piston, to move the piston and apply the front band. Once the transmission is in second gear - Intermediate range, it cannot upshift to third gear regardless of vehicle speed.

SUMMARY

The forward and intermediate clutches and front band are applied. The transmission is in Intermediate range - second gear.

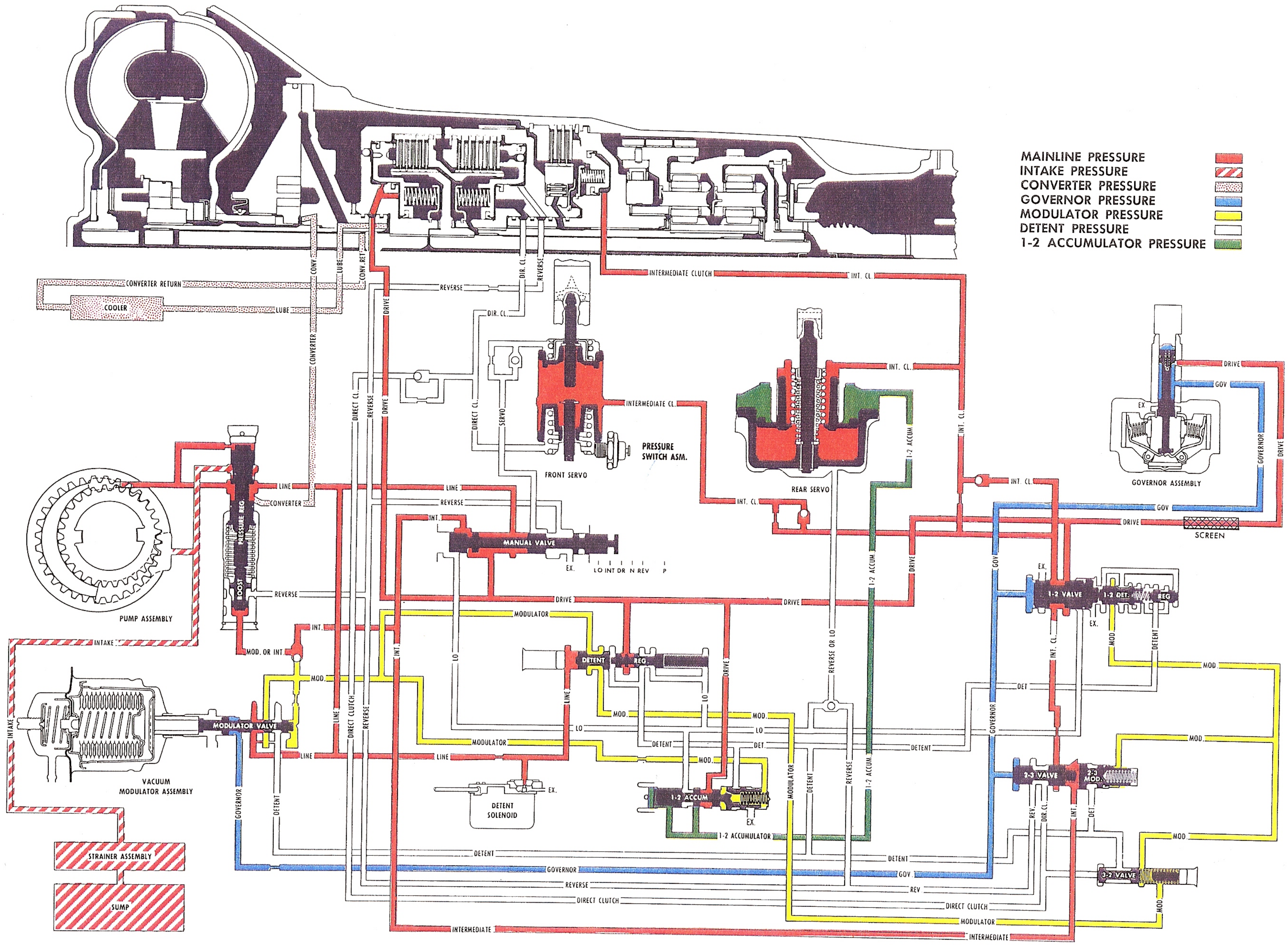



Fig. 65 Intermediate Range - Valves in Second Gear Position

# LO RANGE—FIRST GEAR
## Valves in First Gear Position

| | | |
|---|---|---|
| Forward Clutch - Applied | Direct Clutch - Released | Intermediate Clutch - Released |
| Lo Roller Clutch - Effective | Front Band - Released | Intermediate Sprag - Ineffective. |
| | Rear Band - Applied | |

Maximum downhill braking can be attained at speeds below 40 mph with the selector lever in Lo range position, Lo range oil from the manual valve is then directed as shown in Fig. 66.

1. Rear Servo
2. 1-2 Accumulator Valve
3. Detent Regulator Valve
4. 1-2 Shift Valve

Basic Control

Lo range oil flows past a check ball to the apply side of the rear servo piston and to the 1-2 accumulator valve to raise the 1-2 accumulator oil to line pressure for a smooth band apply.

Lo range oil acts on the detent regulator valve. Combined with the detent spring, Lo range oil holds the detent valve against line oil acting on the detent valve. This causes drive oil to flow through the detent regulator valve into the detent and modulator passages. Modulator and detent oil at line pressure, acting on the 1-2 regulator and 1-2 detent valve, overcomes governor oil and Lo oil on the 1-2 shift valve at speeds below approximately 40 mph and the transmission will shift to first gear.

With the transmission in first gear - Lo range, the transmission cannot upshift to second gear regardless of vehicle or engine speed.

SUMMARY

The forward clutch and rear band are applied. The transmission is in Lo range - first gear.

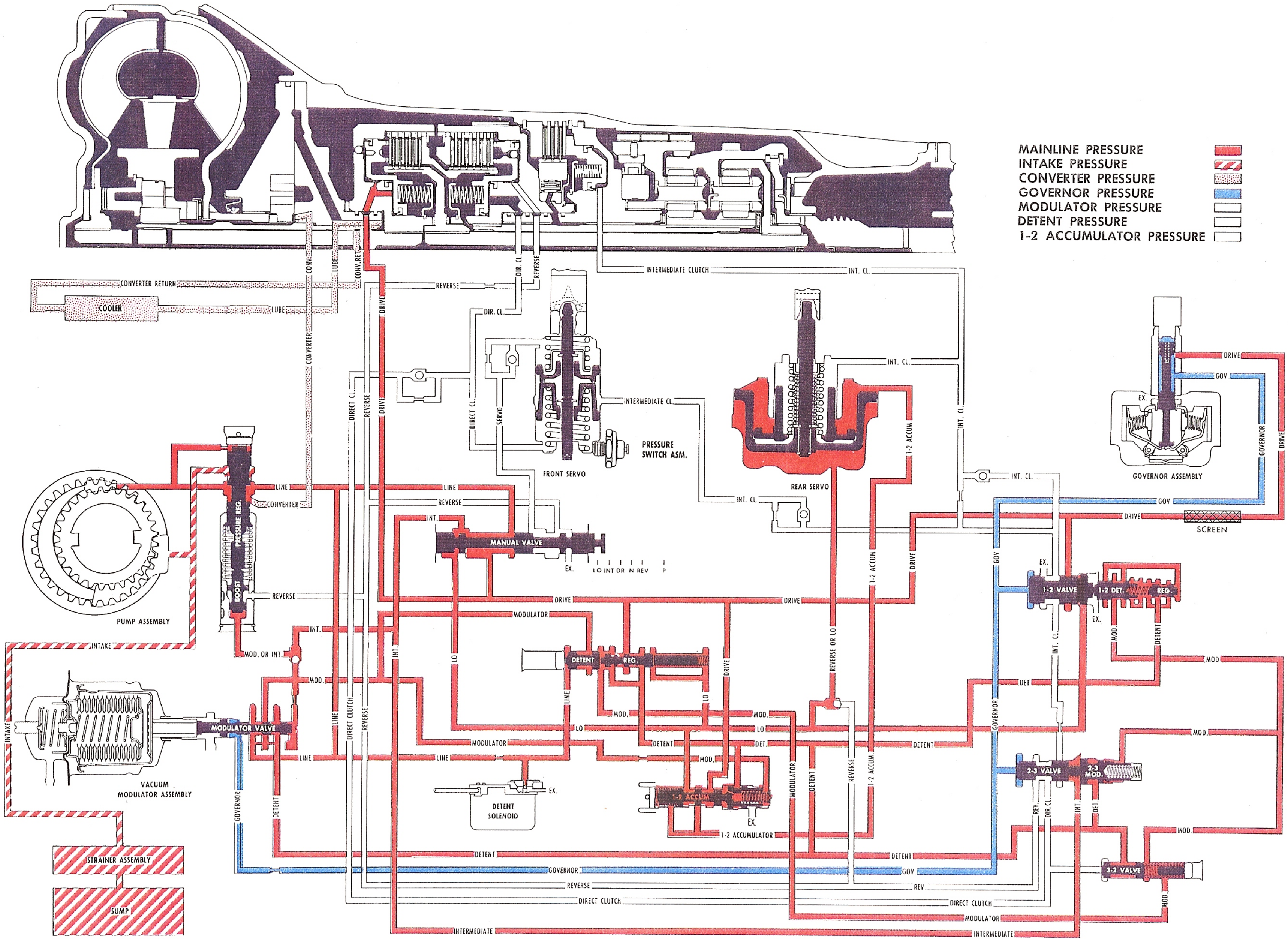
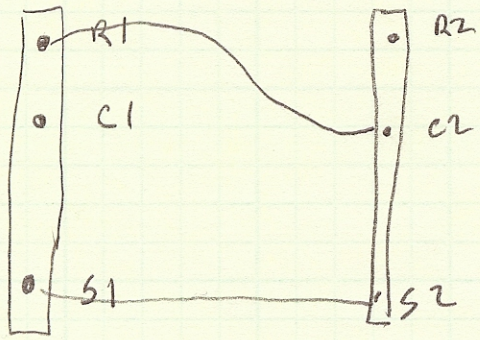



Fig. 66 Lo Range – First Gear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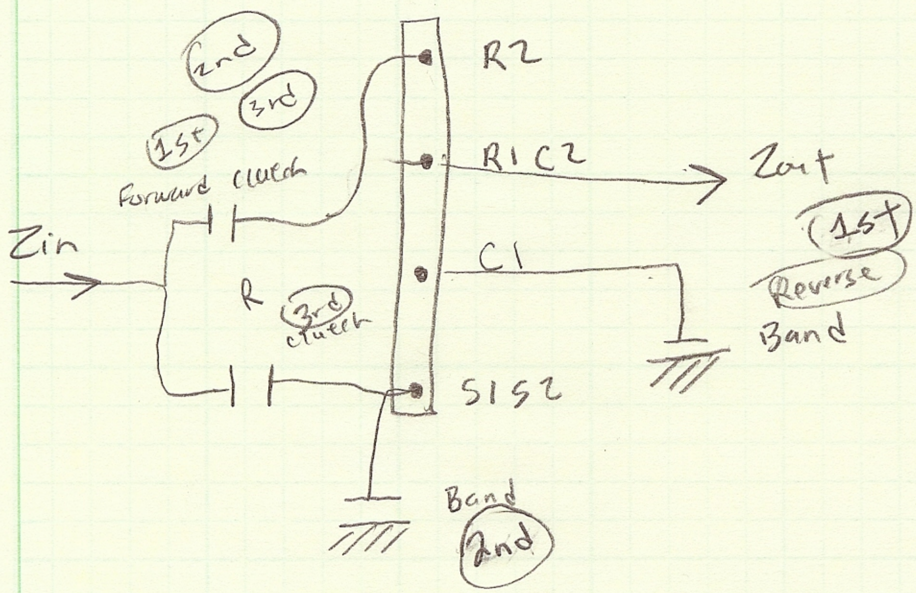
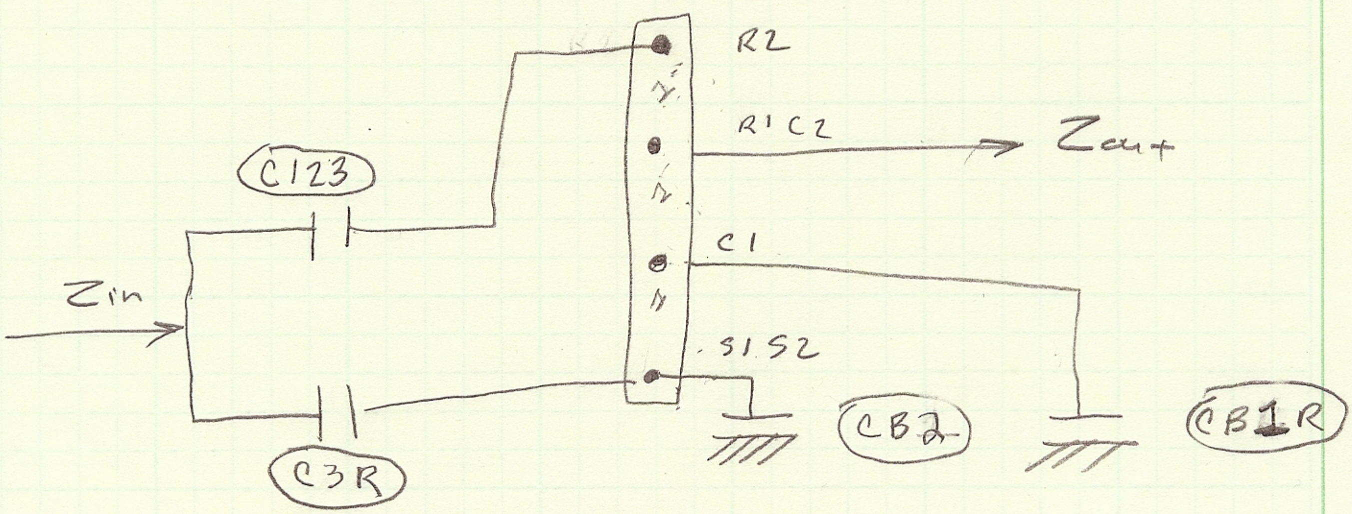
R2
C1
C2
S1
S2


2nd
3rd
1st
Forward clutch
Zin
R
3rd clutch
R2
R1C2
Zout
C1
1st
Reverse
Band
S1S2
Band
2nd

2/1

3/2


R2
R1C2
Zout
C123
Zin
C1
S1S2
CB2
CB1R
C3R

THM 400