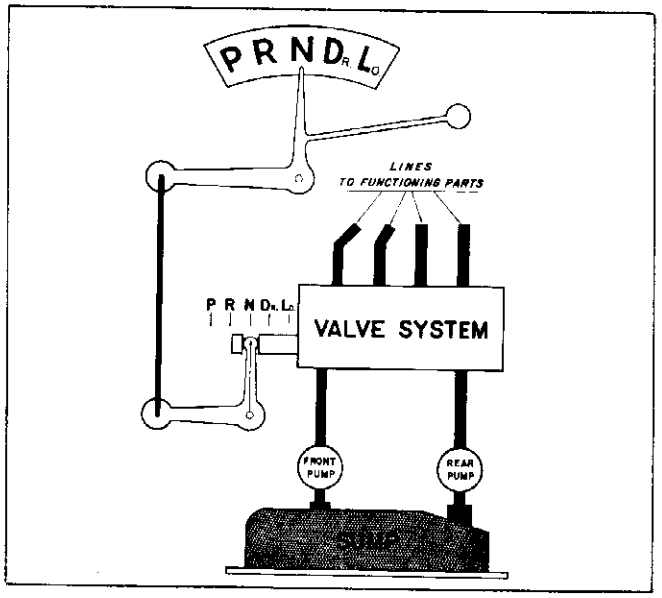
SECTION FOUR—CONTROL SYSTEM

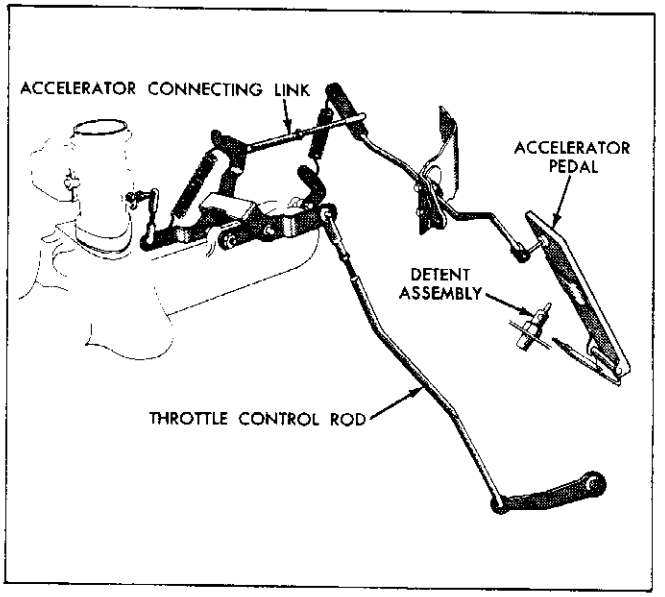
A. General Information

1. The control system consists of manual control linkage, throttle linkage, and a hydraulic control system.



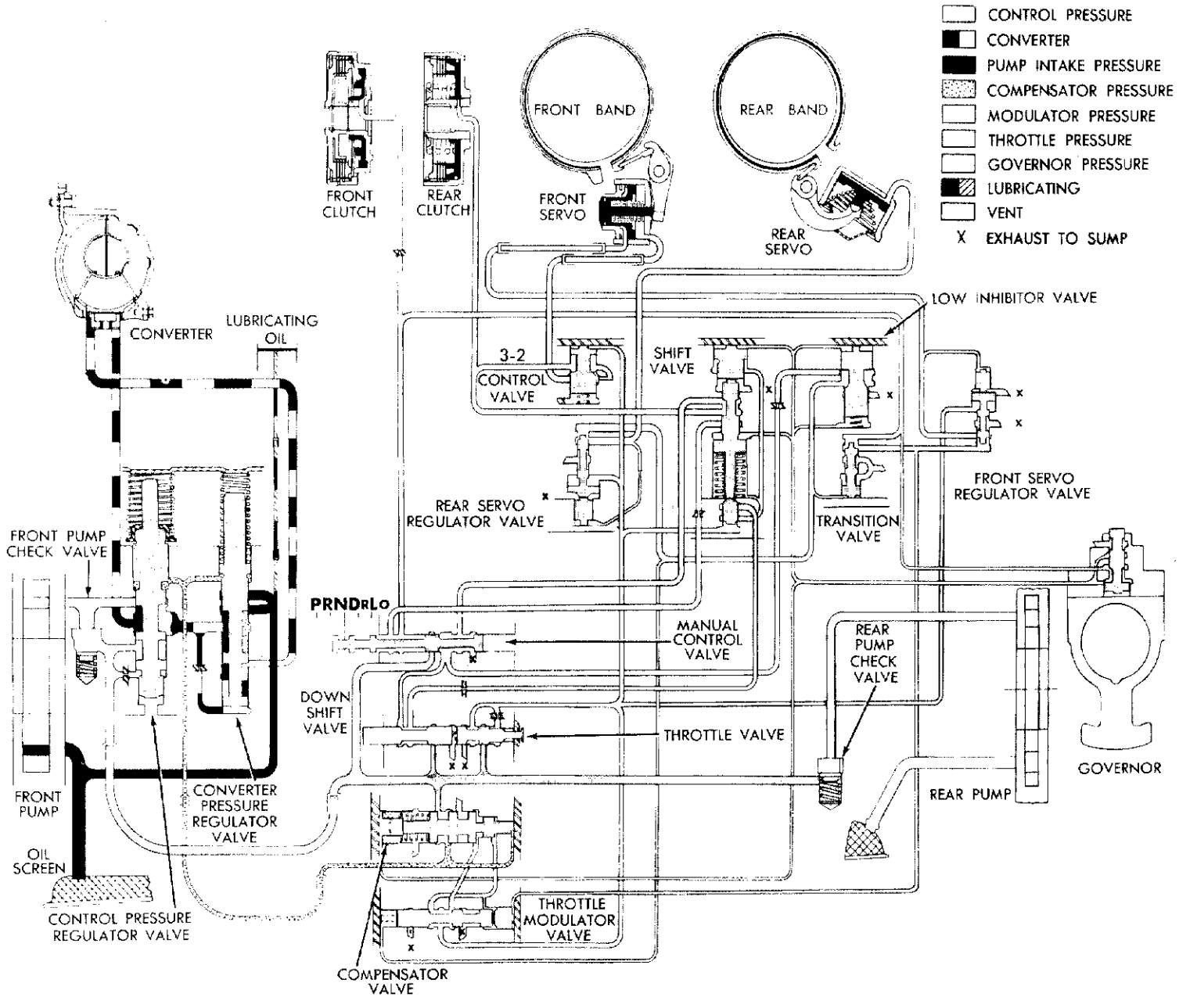
2. The manual control linkage extends from the manual selector to the manual lever on the transmission, and actuates the manual control valve in the control valve body. This linkage is controlled by the selector lever or keyboard, which permits the driver to select the driving range desired -- P (parking), R (reverse), N (neutral), DR (drive), and LO (low).

NOTE The 1957 Mercury uses a keyboard type of selector control.

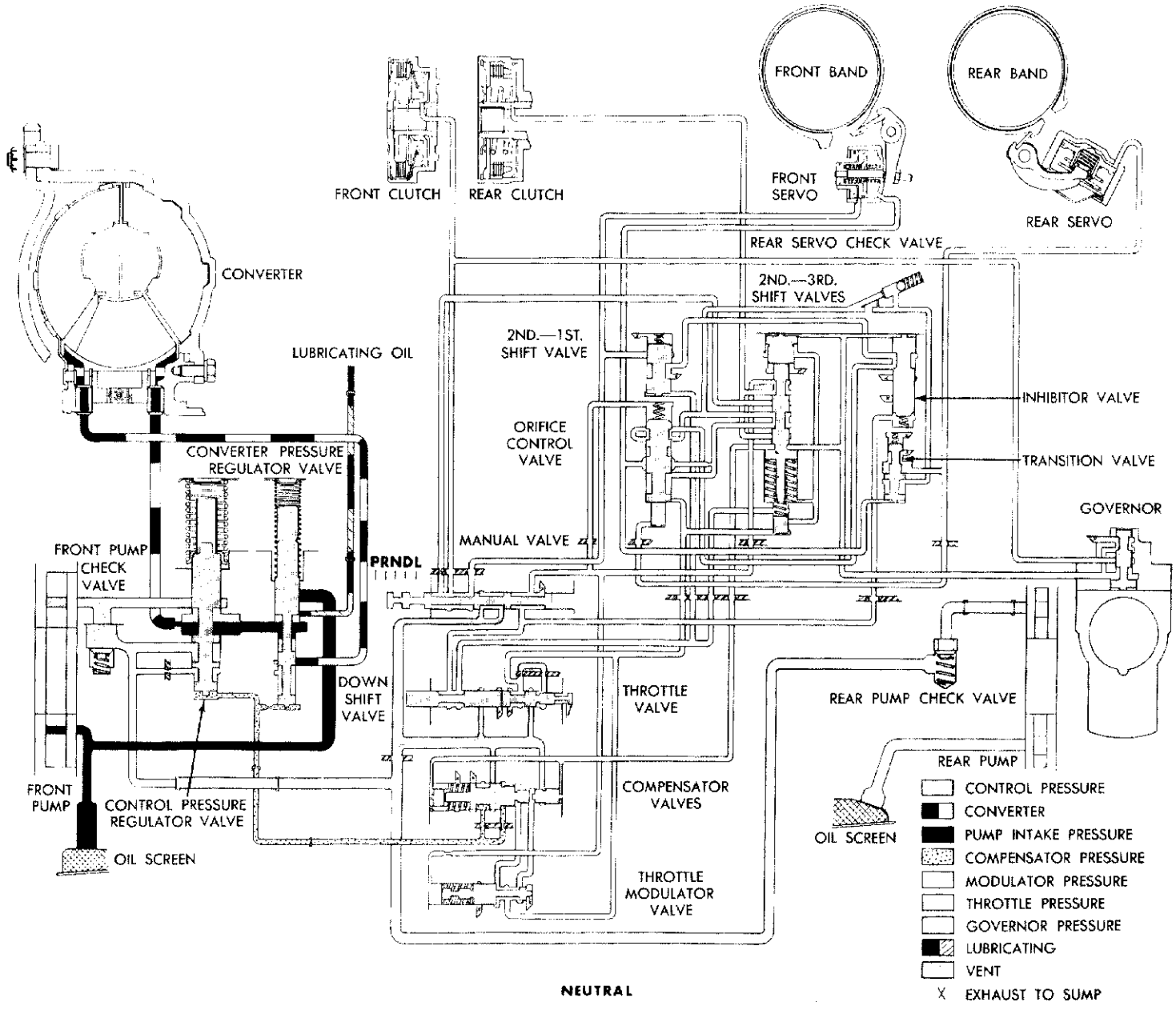


3. The throttle linkage runs from the accelerator foot pedal to the carburetor and the outer throttle lever on the transmission. Through this linkage the relationship of throttle openings and transmission operation is maintained.

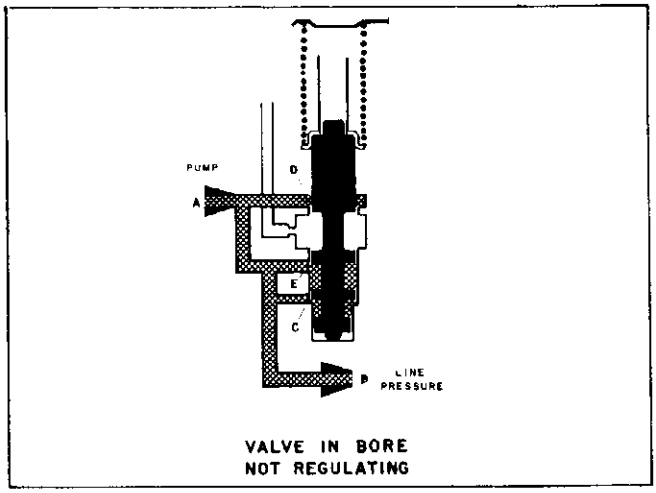
4. The hydraulic control system is made up of hydraulically operated valves, two pumps, and connecting lines and passages. The valves are in the main control valve assembly, the pressure regulator, and the governor body. This system functions in direct response to throttle positions, road speeds, and selector positions to produce automatic shifts. The pictures on the following two pages provide an over-all view of the hydraulic control systems for the years 1951 through 1954 and for the years 1955 through 1957.



Hydraulic System of Transmissions from 1951 through 1954



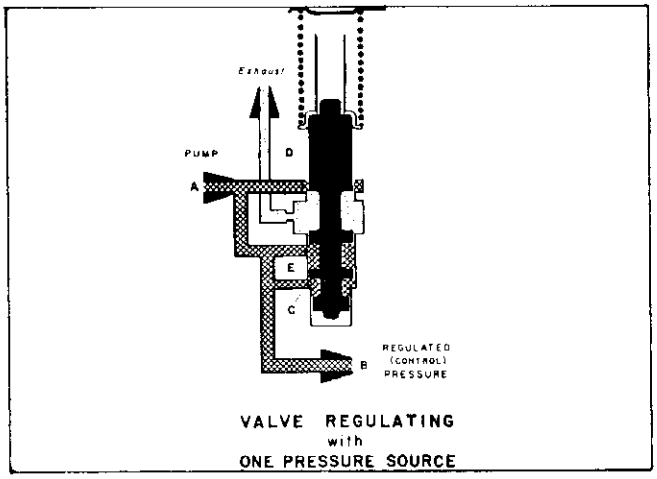
Hydraulic System of Transmissions After 1954



VALVE IN BORE
NOT REGULATING

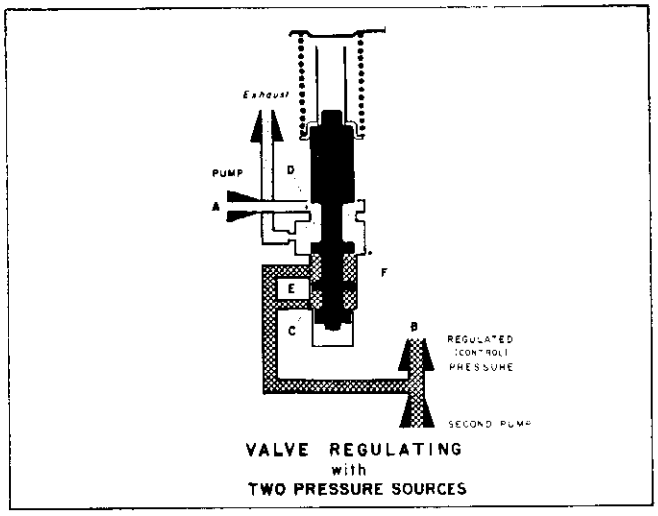
5. Before getting into the details of the hydraulic system, let's examine how a typical hydraulically-regulated valve works under various conditions.

(a) Valve in bore not regulating. Fluid from the pump is directed to the valve at "C", "D", and "E". Fluid is cut off by the land at "D". The fluid enters the valve bore at "C" to oppose spring force, but hasn't enough pressure to move the valve. Note that the pressure at "A" and "B" are equal.



VALVE REGULATING
with
ONE PRESSURE SOURCE

(b) Valve regulating with one pressure source. As the pump builds up enough pressure at "C", the spring force is overcome and the valve moves. This opens the port at "D", fluid exhausts through the valve, and the pressure drops at "B" and "C". This lowered pressure cannot move the valve any further against spring force, and the pressure at "C" balances spring force. As pump volume varies, the valve will automatically position itself so that enough fluid will exhaust at port "D" to maintain constant pressure at "B" and "C". Thus spring force actually controls the pressure produced.



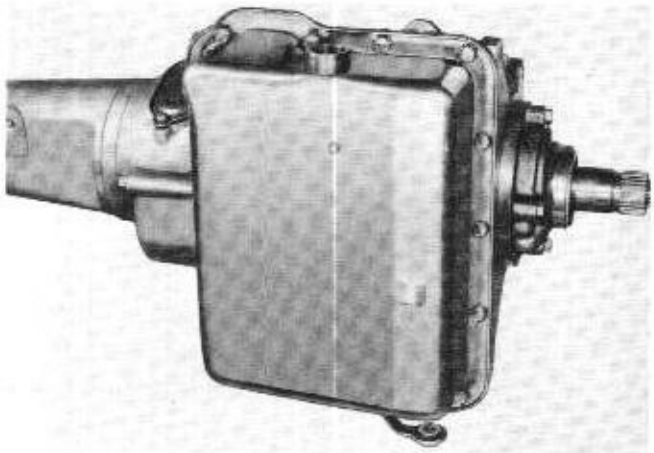
VALVE REGULATING
with
TWO PRESSURE SOURCES

(c) Valve regulating with two pressure sources. The fluid at "C" again pushes the valve against the spring. But the fluid at "E", which formerly had no effect, now escapes at "F" to limit the pressure rise. Under these conditions fluid from the first source exhausts through the open port "D" without restraint.

Now, let's trace the basic circuits in a step-by-step manner tracing fluid pressures and showing operation of the various valves.

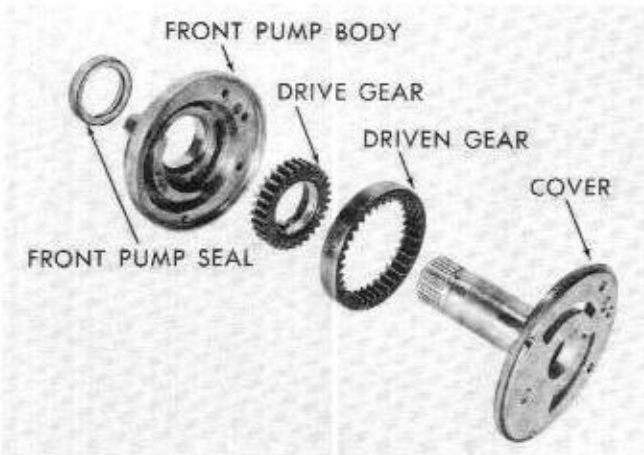
B. Components of Hydraulic Control System

Basically there are three requirements in any automatic transmission control system -- a source of fluid (oil), a pump (or pumps) to deliver fluid under pressure, and a system of valves to control pressure and distribute fluid. The components that perform these functions are as follows:

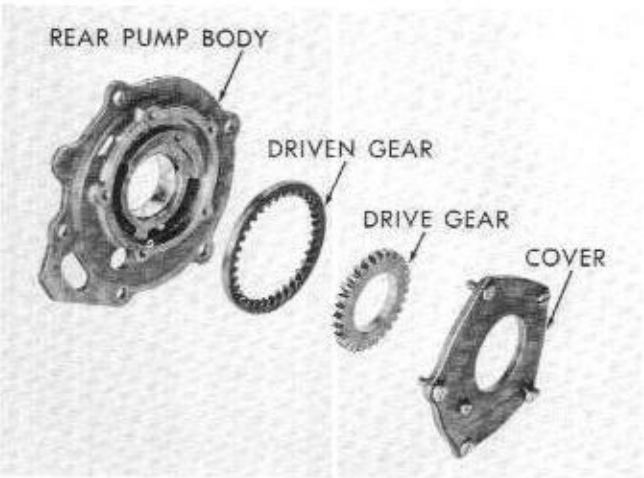


1. The bottom oil pan (sump) -- bolted to the bottom of the transmission -- is the source of the fluid.

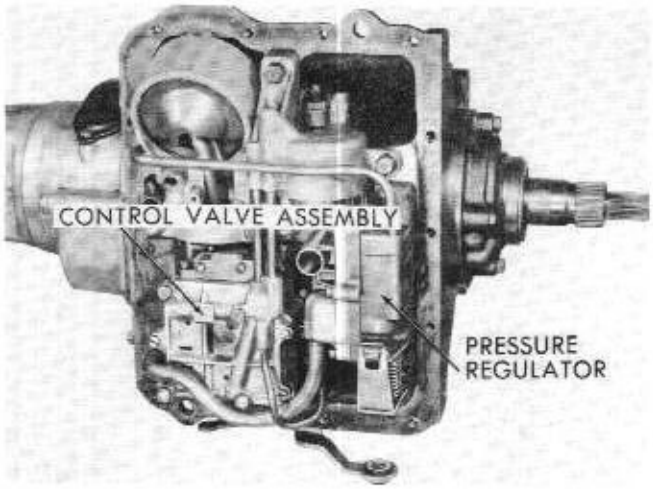
2. Two gear type pumps (front and rear) deliver fluid under pressure.



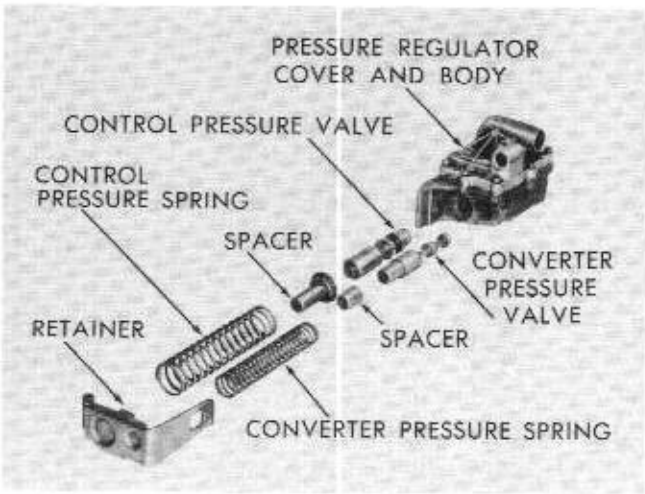
(a) The front pump, driven by the impeller, rotates at engine speed and operates only when the engine is running. Therefore, the greater the engine speed the greater the volume of fluid delivered by the front pump to the control system. The front pump has greater capacity than the rear, for it supplies all the fluid for low speeds and reverse.



(b) The rear pump, driven by the output shaft, delivers fluid to the system only when the car is moving forward. As car speed increases, rear pump volume increases until there is enough pressure to open the rear pump check valves. The rear pump then supplies fluid for control pressure and the front pump supplies fluid for converter pressure and transmission lubrication. When the car is started by pushing, the rear pump supplies all the fluid until the engine starts.

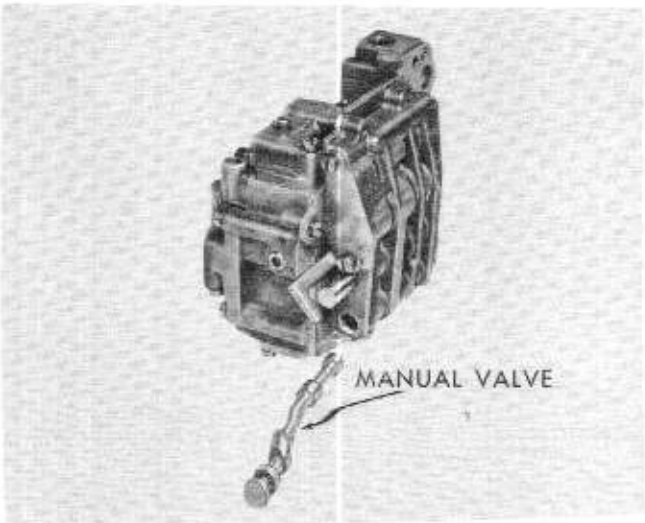


3. To control the pressure and distribution of fluid, valves located in the pressure regulator, governor and control valve assemblies are incorporated in the system.

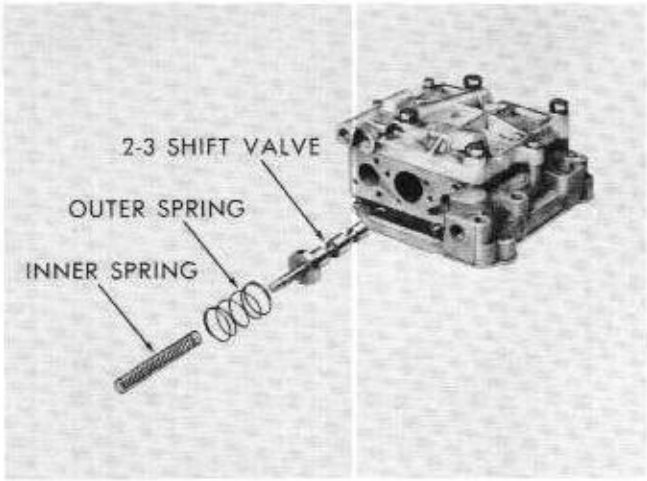


(a) The spring loaded control pressure regulator valve, located in the pressure regulator assembly, regulates the pressure of fluid from the pumps.

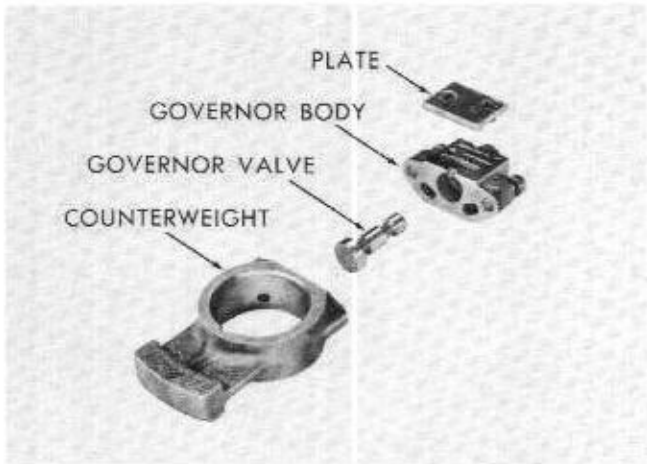
(b) The spring loaded converter pressure regulator valve, also located in the pressure regulator assembly, controls converter oil pressure and provides fluid to lubricate the entire transmission.



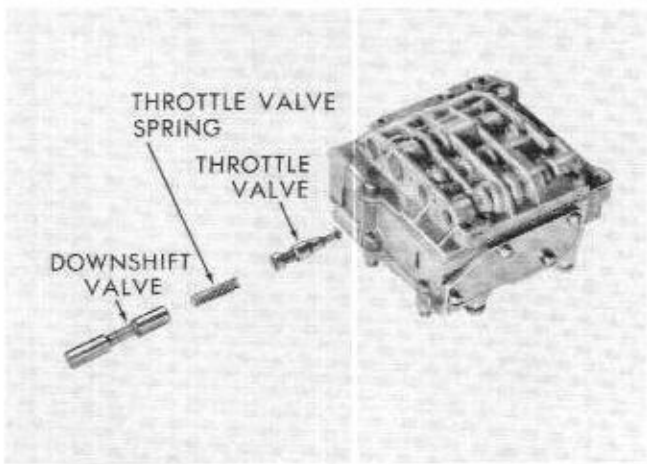
(c) The manual valve, located in the control valve body, is actuated by the selector linkage, and distributes control pressure fluid in accordance with the selector position.



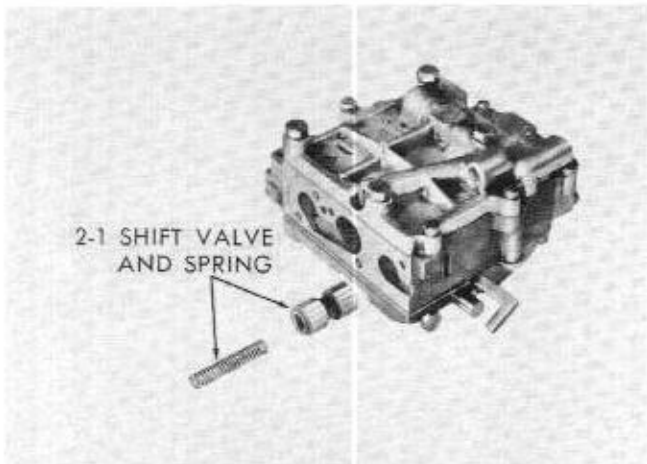
(d) The 2-3 shift valve, located in the control valve body, automatically shifts the transmission from intermediate to high at the most efficient point under varying operating conditions.



(e) The governor valve provides governor pressure which controls transmission operation in accordance with road speeds. Since the governor is attached to the output shaft, the faster the car moves the faster the governor turns.

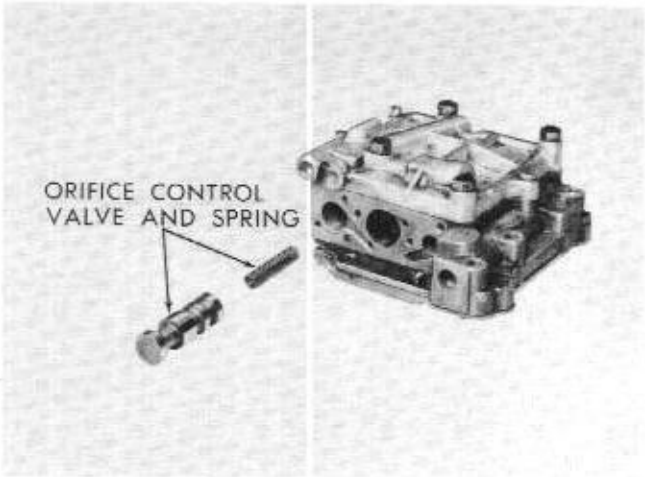


(f) The downshift valve and throttle valve are both located in the same control valve body bore. The throttle valve provides throttle pressure which controls transmission operation according to throttle openings. The downshift valve makes possible forced full throttle downshifts to provide fast acceleration.



(g) A 2-1 shift valve, located in the control valve body, makes possible an automatic full throttle low ratio start with the selector in drive. It also makes possible a kickdown from intermediate to low at speeds below approximately 16 m.p.h.

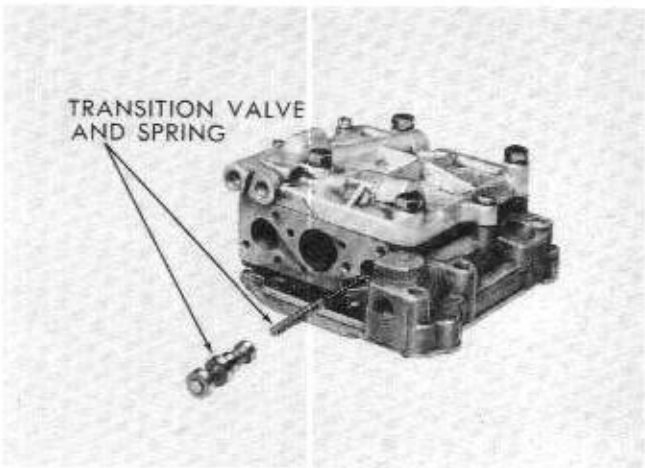
NOTE This 2-1 shift valve is not in pre-1955 models.



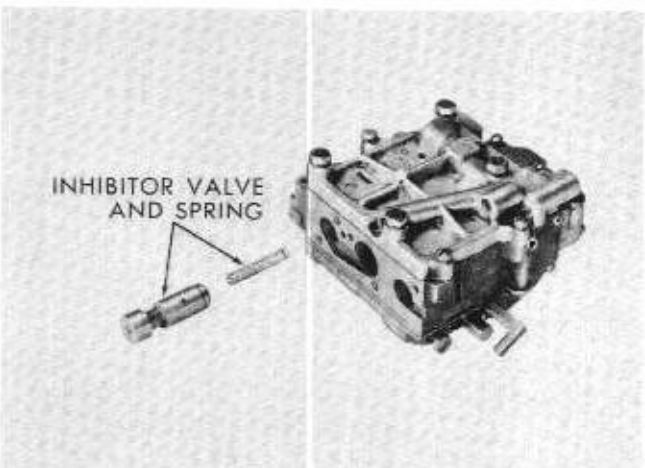
(h) The orifice control valve, located in the control valve assembly, times band operation during various downshifts. During a normal 3-2 downshift, with a closed throttle, front servo release fluid slowly exhausts through a small orifice to provide smooth front band application.

During a 3-2 downshift at open throttle, the orifice control valve, moved by throttle pressure, allows unrestricted flow of front servo release fluid to provide rapid front band application. During a manual shift from intermediate to low, with closed throttle, the orifice control valve momentarily restricts fluid flow. This times the application of the rear servo and the release of the front servo to provide smooth rear band application.

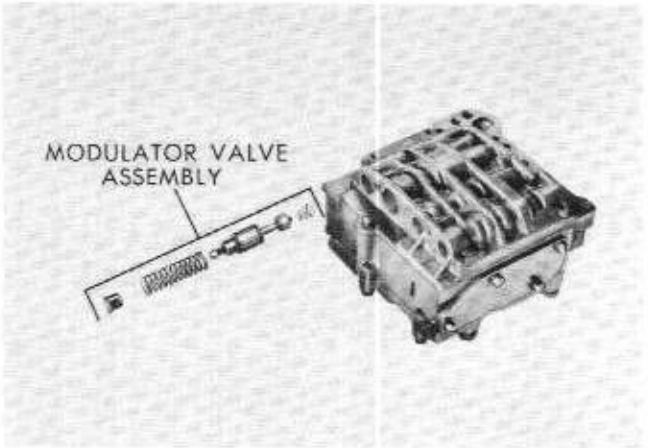
NOTE The orifice control valve is not in pre-1955 models.



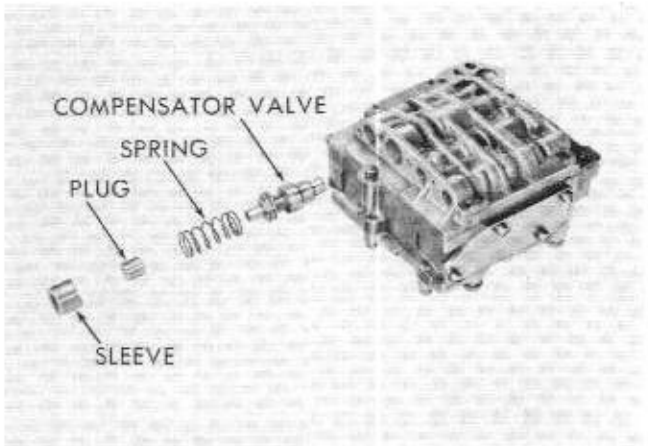
(i) The transition valve, located in the control valve body, prevents application of two bands at the same time.



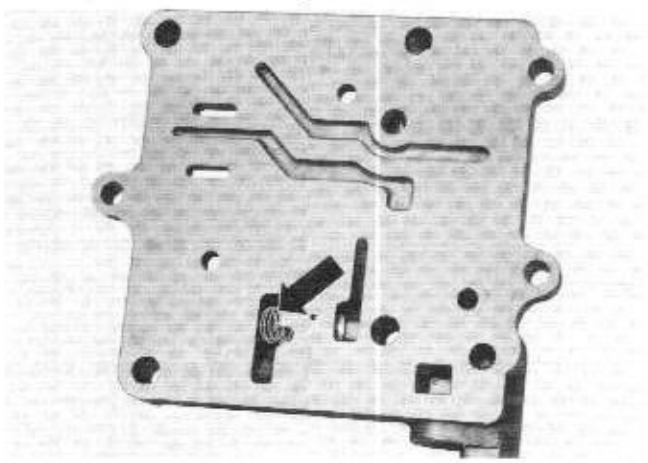
(j) The low inhibitor valve, located in the control valve body, prevents a shift into low above approximately 25 m.p.h.



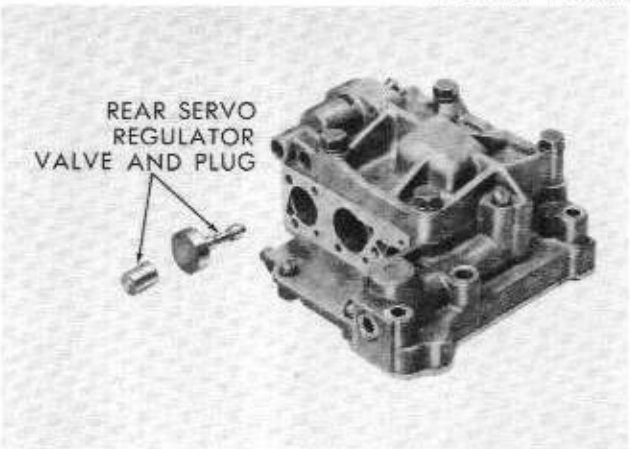
(k) The throttle modulator valve, located in the valve body, serves to modulate (regulate) throttle pressure under various driving conditions.



(l) The compensator valve, located in the valve body, adjusts control pressure in accordance with throttle opening, road speed, and manual control valve position.

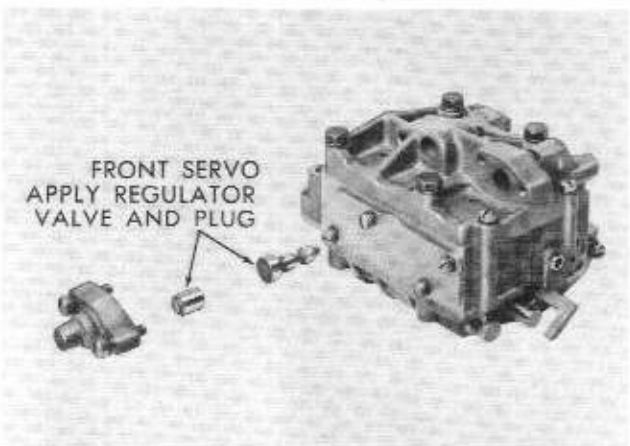


(m) The rear servo check valve, used in models after 1954, controls the flow of rear servo release fluid during light throttle shifts.

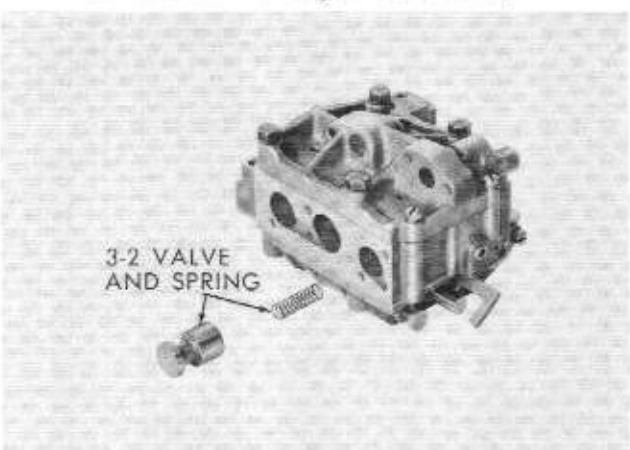


NOTE The following valves (n, o, p) were used in pre-1955 models.

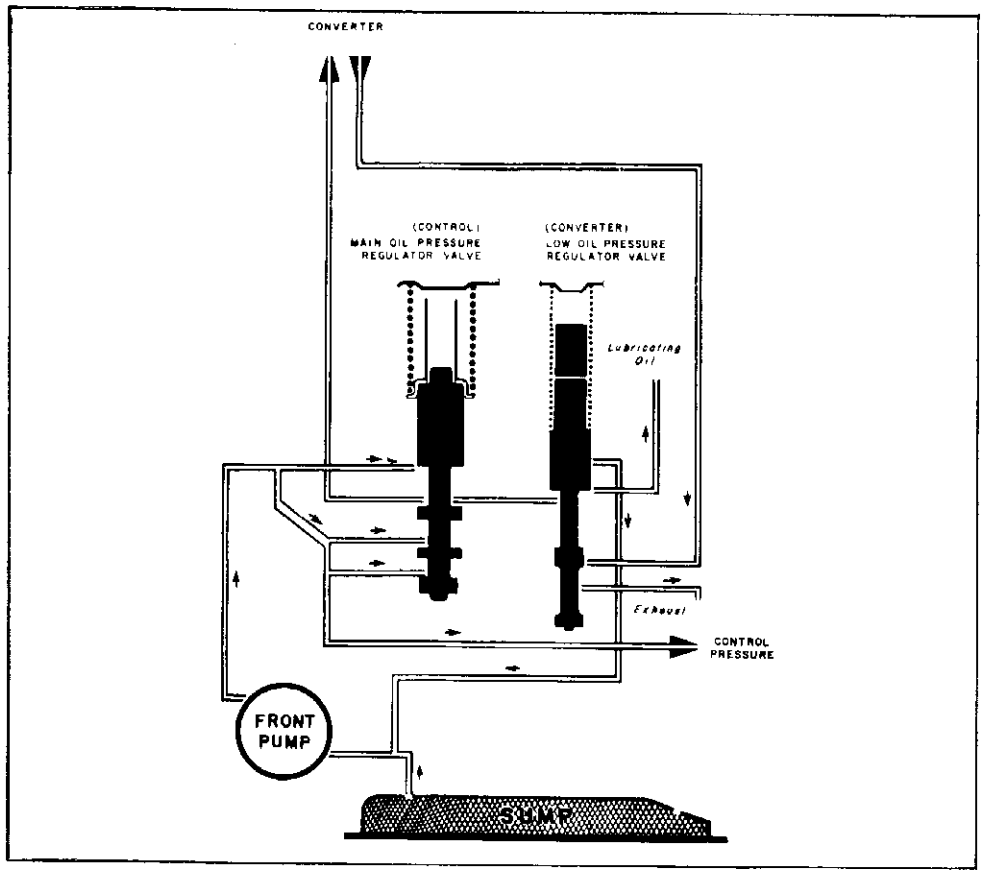
(n) A rear servo regulator valve was used to cushion the application of the rear band at light throttle.



(o) The front servo regulator valve was used to cushion application of the front band at light throttle.



(p) The 3-2 control valve times band operation during a closed throttle 3-2 downshift.

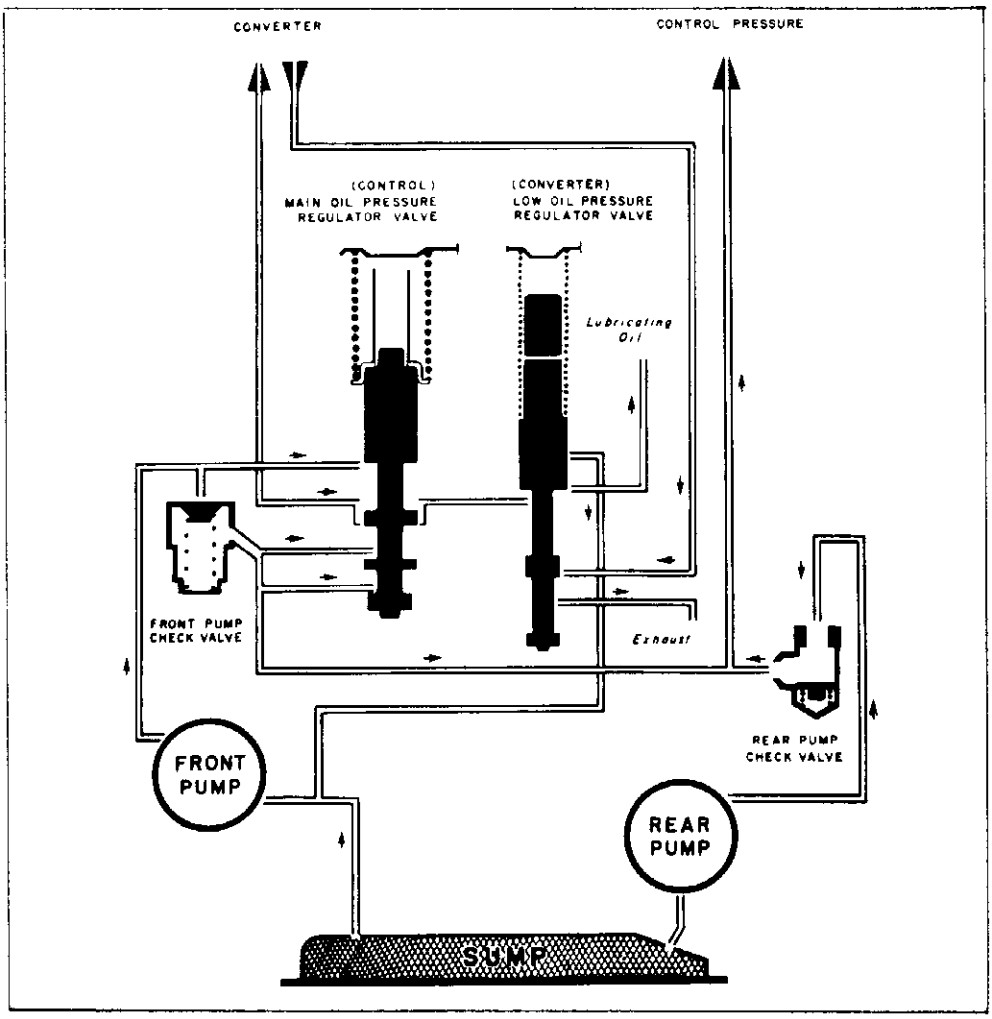


C. Hydraulic Pressures

1. Control pressure and converter pressure (with front pump supplying all fluid).

   (a) The front pump, rotating at engine speed, delivers fluid to the control pressure regulator valve, which regulates the pressure of the fluid. This spring-loaded valve prevents excessive line pressure by exhausting the excess volume of fluid. This line pressure is called control pressure.

   (b) The exhaust fluid from the control pressure regulator valve flows through the converter pressure regulator valve and into a passage which leads to the converter. Fluid fills the converter and the converter return line. This return line leads to the converter pressure regulator valve but is cut off by a land. Pressure builds up in the converter and in its inlet and return lines as soon as they are filled. This pressure overcomes the converter pressure regulator spring and opens the valve by acting against its large face. This uncovers a passage which supplies lubrication to the transmission. After all lubrication lines are filled, the valve moves farther and the excess fluid from the converter return line exhausts directly to the sump. Additional movement of the valve is possible which allows fluid to by-pass directly to the inlet side of the pump.

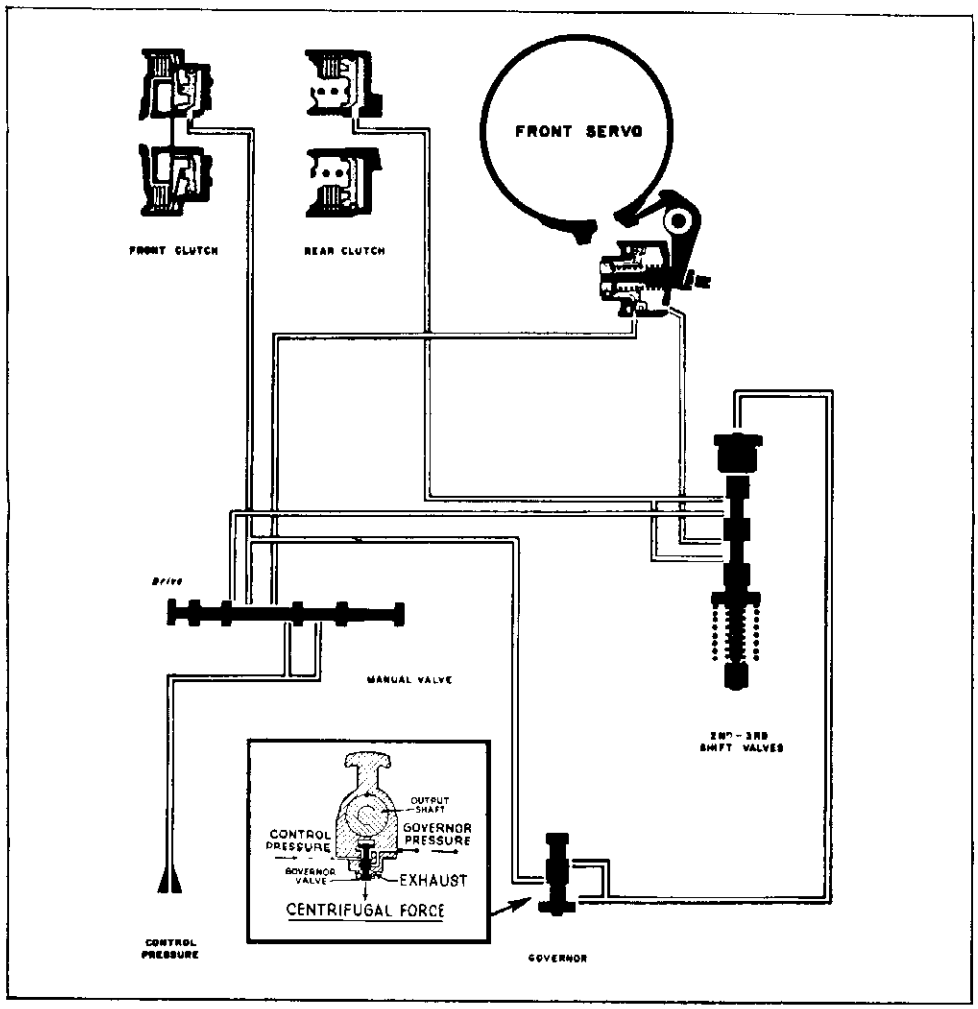


2. Control pressure and converter pressure (with both pumps working).

   (a) As mentioned, the front pump supplies all fluid when the car is standing still, starting up, or is in reverse. The rear pump, driven by the output shaft, takes over part of the load for normal driving. When it's necessary to start the car by pushing, the rear pump supplies all fluid for transmission operation until the engine starts.

   (b) As the car begins moving, the volume of fluid from the front pump supplies all requirements of the transmission and converter.

   (c) When road speed increases sufficiently, rear pump output will open the rear check valve allowing the rear pump fluid to flow to the control pressure regulator valve and also close the front check valve. This causes the rear pump to supply all of the fluid for control pressure and the front pump to supply only the lower converter pressure and lubrication fluid -- thus reducing the load on the front pump and saving power. When operating in this manner the control pressure is regulated by exhausting the excess volume to the converter as shown in the lower picture, page 24.

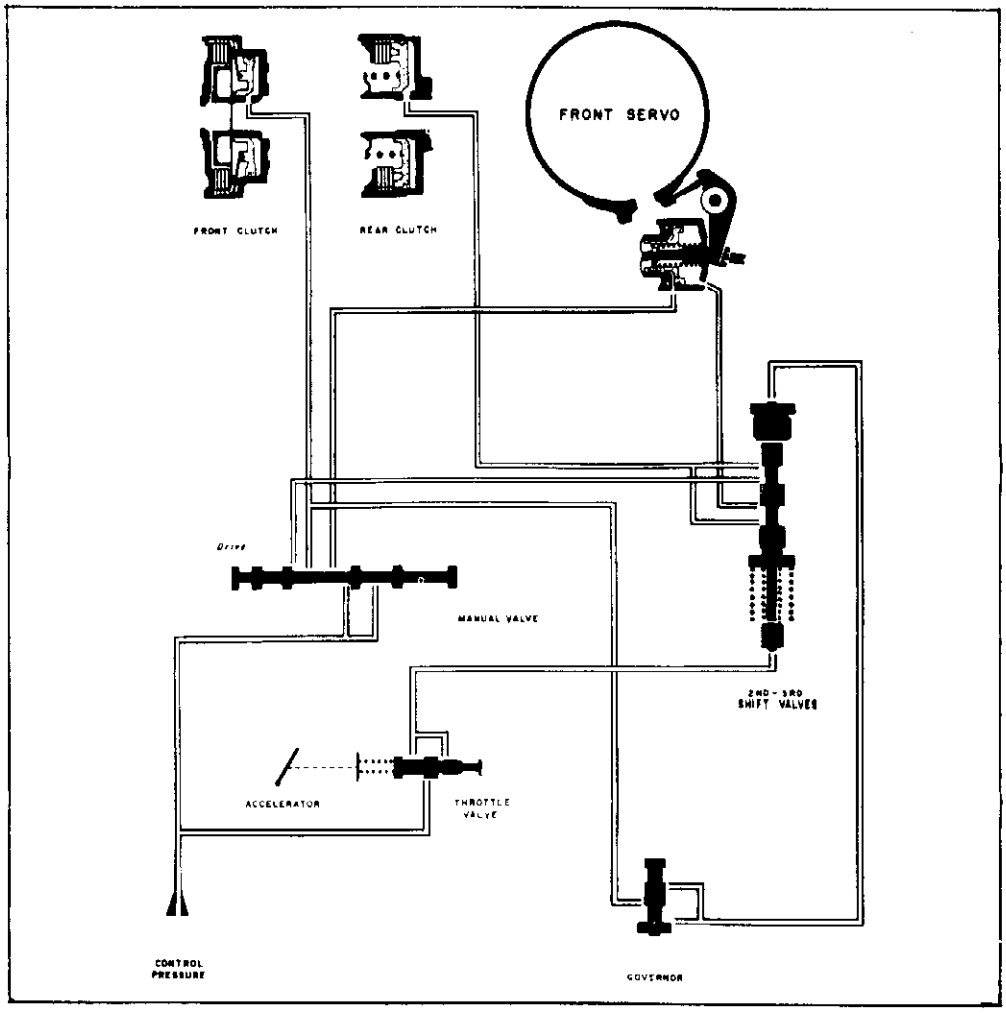


3. Governor Pressure.

(a) Because the shift valve is held closed by spring pressure, a force related to car speed must be used to open the 2-3 shift valve and provide ratio change. To accomplish this a hydraulic governor is attached to the output shaft.

(b) When the manual control valve is in any forward position, it supplies the governor with control pressure. When the governor is not rotating (the car is standing still), no governor pressure is supplied. As the car moves and speed increases, the governor rotates. This creates centrifugal force, which acts upon the governor valve to regulate pressure in direct proportion to centrifugal force. This pressure, which varies with the speed of the car, is called governor pressure.

(c) Governor pressure is directed to the 2-3 shift valve on the side opposite the shift valve spring. Now the shift valve is between two opposing forces -- shift valve spring force and governor pressure. The shift from intermediate to high occurs when governor pressure overcomes spring resistance. From this, it can be seen that the spring actually controls the speed at which the shift occurs.

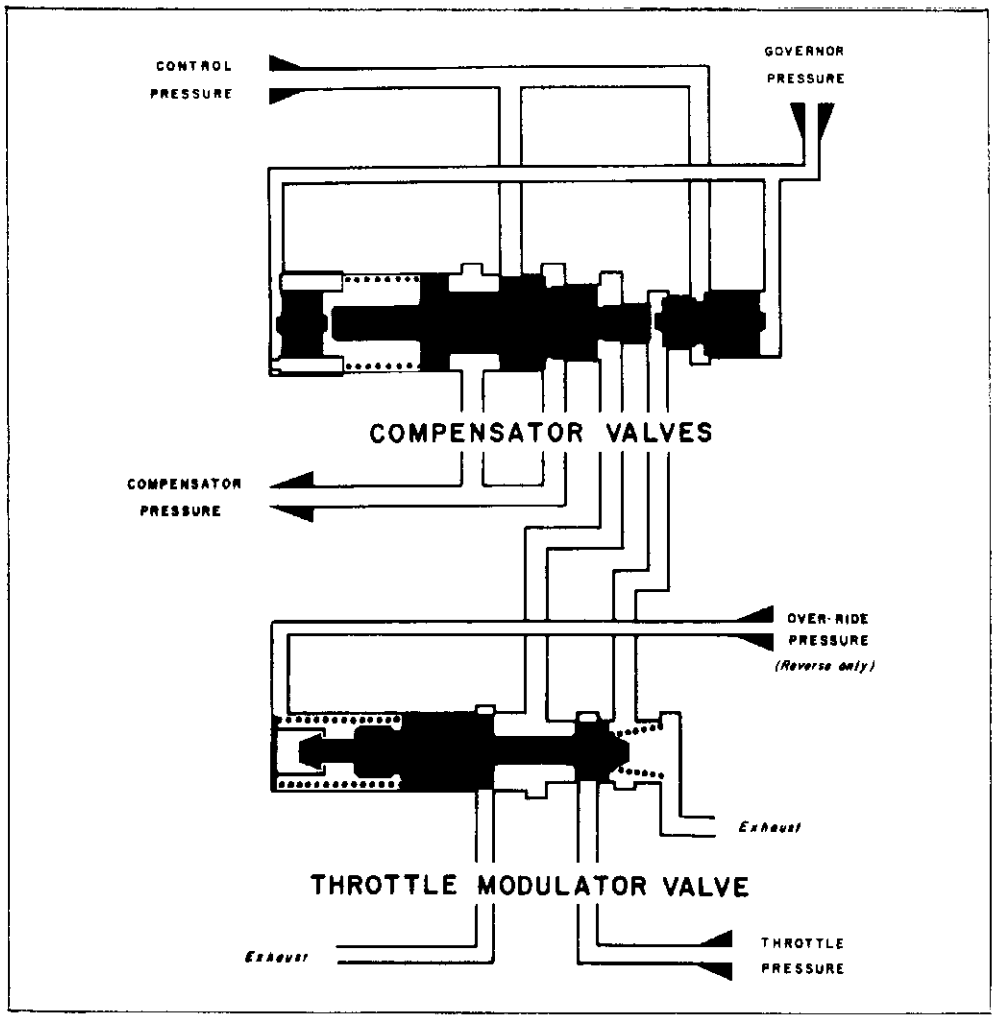


4. Throttle Pressure.

(a) If the 2-3 shift valve spring alone controlled the shift point, then the shift would always occur at the same road speed. This is not desirable, for shifts should also vary with throttle openings to provide maximum performance and economy. To accomplish this, a throttle valve is used.

(b) The throttle valve is actuated by a spring which is compressed by the accelerator pedal through the throttle linkage. Control pressure is directed to the throttle valve, and when the accelerator pedal is completely released this pressure can't pass the throttle valve. As the accelerator is pushed down, the force of the throttle valve spring increases and the throttle valve changes control pressure into a pressure which varies in direct proportion to the amount of throttle opening. This pressure is called throttle pressure.

(c) Throttle pressure is directed to the plug on the spring side of the shift valve. Throttle pressure and the spring work together against governor pressure to hold the valve closed. Thus, the road speed at which ratio change takes place now varies with the throttle opening, and so with more throttle opening the shift will take place at a higher road speed than it will with a light throttle opening.



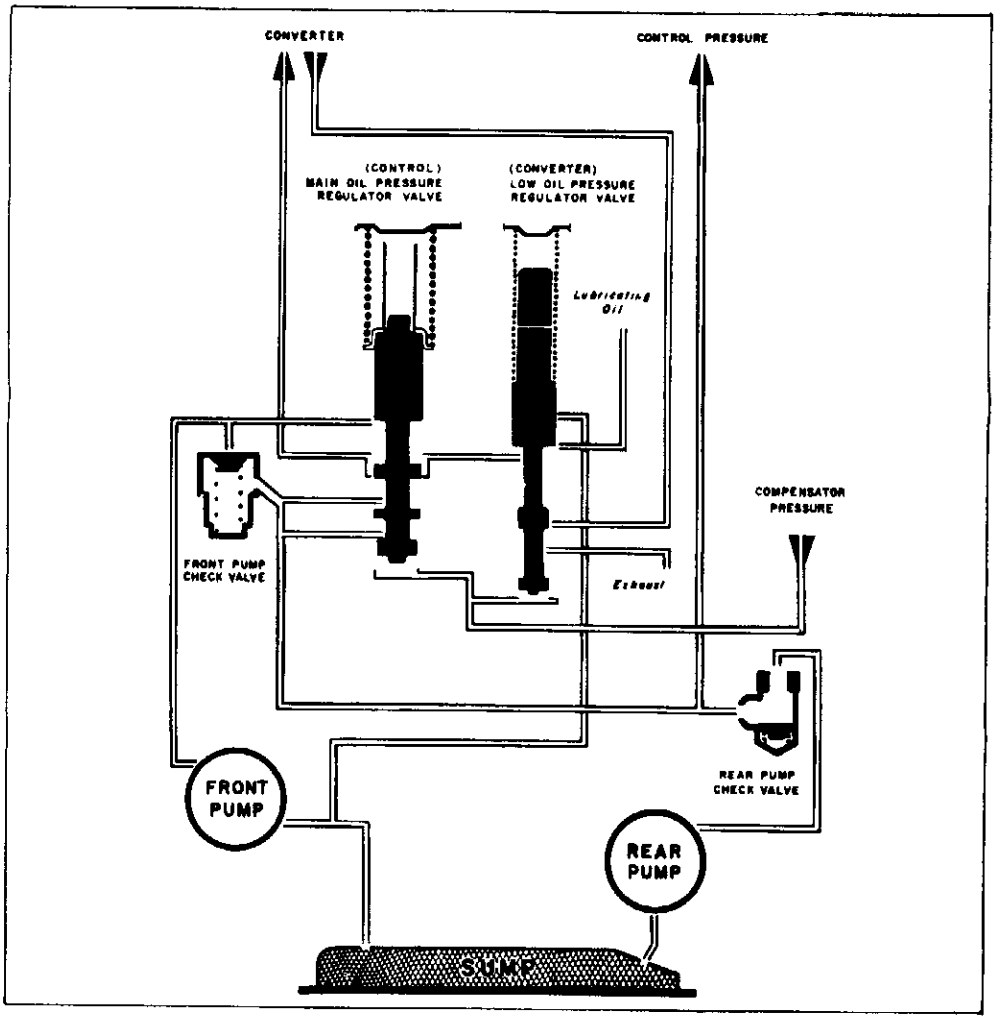
5. Throttle Modulator Pressure.

(a) The modulator valve varies throttle pressures according to the position of the manual control valve.

(b) When the manual control valve is in low and drive positions, the modulator valve reduces throttle pressure and directs it to one face of the compensator valve.

NOTE In 1951-54 models, modulated throttle is produced in drive only.

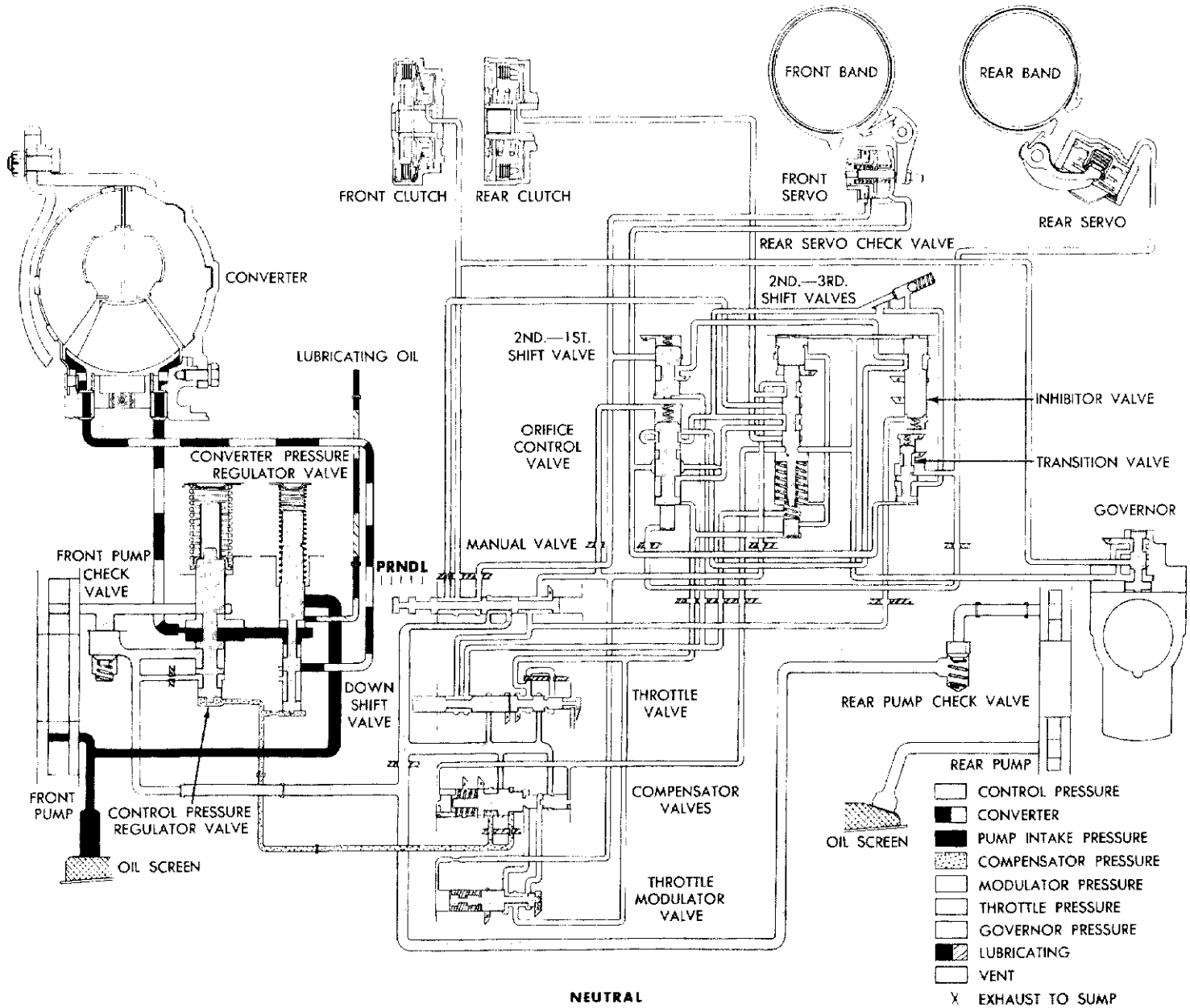
(c) In reverse, the manual control valve directs pressure to the spring end of the modulator valve to assist the spring in moving the valve. Throttle pressure can then pass without restraint to two faces on the compensator valve. Thus, throttle pressure is not modulated in reverse.



6. Compensator Pressure.
   (a) The intensity with which the clutches and bands are applied must vary with throttle opening, road speed, and the position of the manual valve. Under high torque operating conditions, the bands and clutches must be applied with greater force to avoid slippage. Under low torque operating conditions, the transmission will operate more smoothly and efficiently if less force is used to apply the bands and clutches.
   (b) To vary the force with which bands and clutches are applied, control pressure must be varied.
   (c) Control pressure is varied by compensator pressure.
   (d) Compensator pressure is produced by the compensator valve which operates in accordance with road speed, throttle opening, and position of the manual valve.
   (e) Compensator pressure is directed to the control pressure and converter pressure regulator valves, causing them to vary control pressure and converter pressure in accordance with torque conditions.
   (f) Thus, when control pressure is varied, the apply force of the bands and clutches is varied accordingly. The same pressure variations occur with converter pressure to improve converter efficiency and operation.

D. Basic Hydraulic Circuits

Basic Hydraulic Circuit in Neutral (1955-1957 Models)

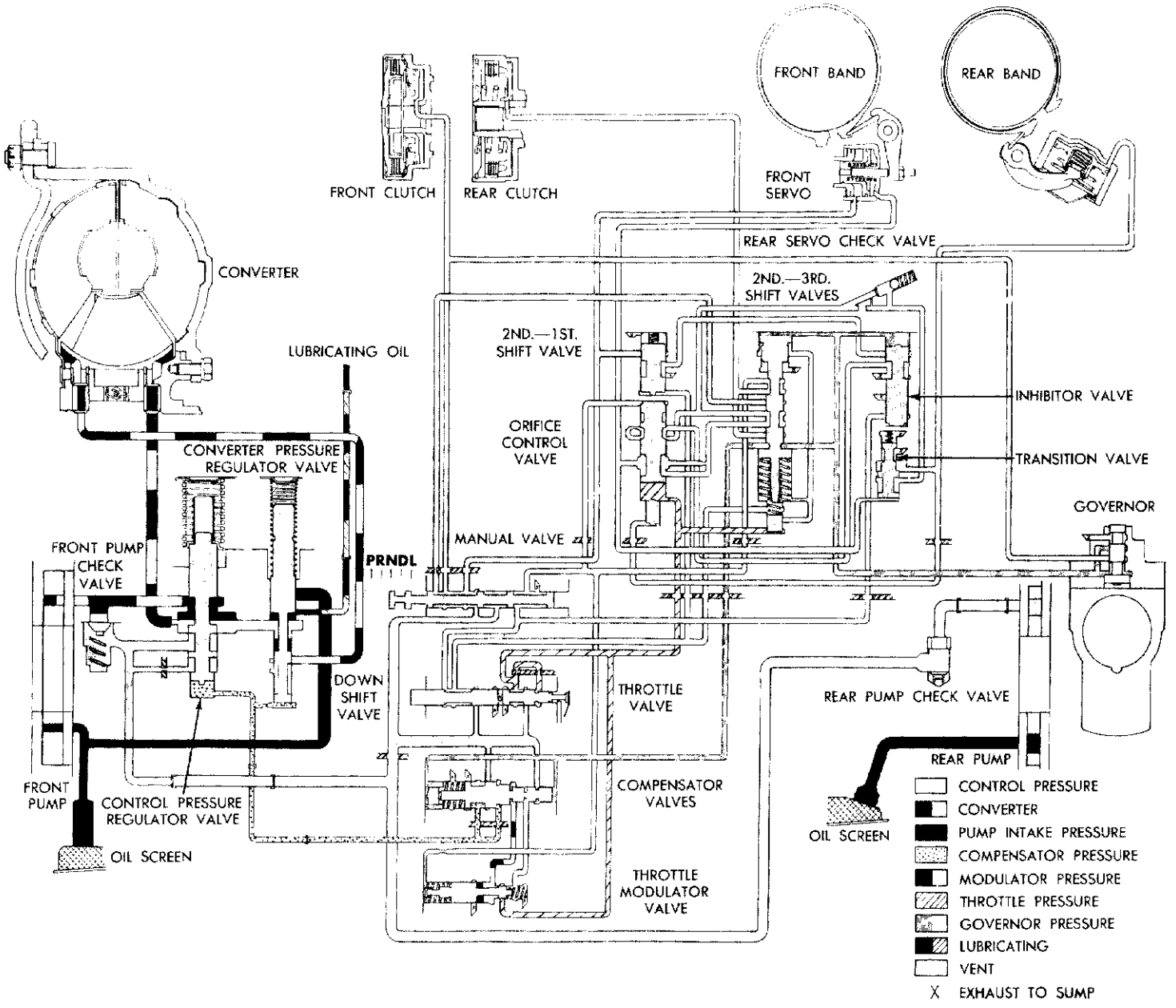


Basic Hydraulic Circuit in Neutral

With the engine running and the selector lever in "N" (neutral) position the following actions take place in the transmission:

1. The front pump delivers fluid to the control pressure regulator, the manual valve, the downshift valve, the throttle valve, and the compensator valve.
2. Compensator pressure is delivered from the compensator valve to the control pressure regulator and the converter pressure regulator.
3. The front pump delivers more fluid than needed to maintain control pressure. So the control pressure regulator valve (aided by compensator pressure) moves against its spring and allows excess fluid to flow to the converter. With the converter filled, the converter regulator valve (aided by compensator pressure) moves against its spring and opens a passage which allows fluid to flow to the transmission lubrication system. Excess volume is exhausted to the cooler and then to the sump. Under certain conditions additional fluid can be exhausted to the intake side of the front pump.
4. The manual valve, in "N" (neutral) position, blocks any fluid flow to the clutches and servos. The clutches and the bands, with no fluid pressure being applied, are held in release by spring force. Thus no drive is possible through the transmission.

Basic Hydraulic Circuit in Drive Range -- Intermediate Ratio (1955-1957 Models)



Basic Hydraulic Circuit in Drive Range -- Intermediate Ratio

With the selector in drive position, the manual valve is also in drive position, and now allows control pressure to flow through a common passage to --

1. The front clutch
2. The governor valve

NOTE This passage from the manual valve is always open in all forward ratios.

The manual valve also directs pressure to --

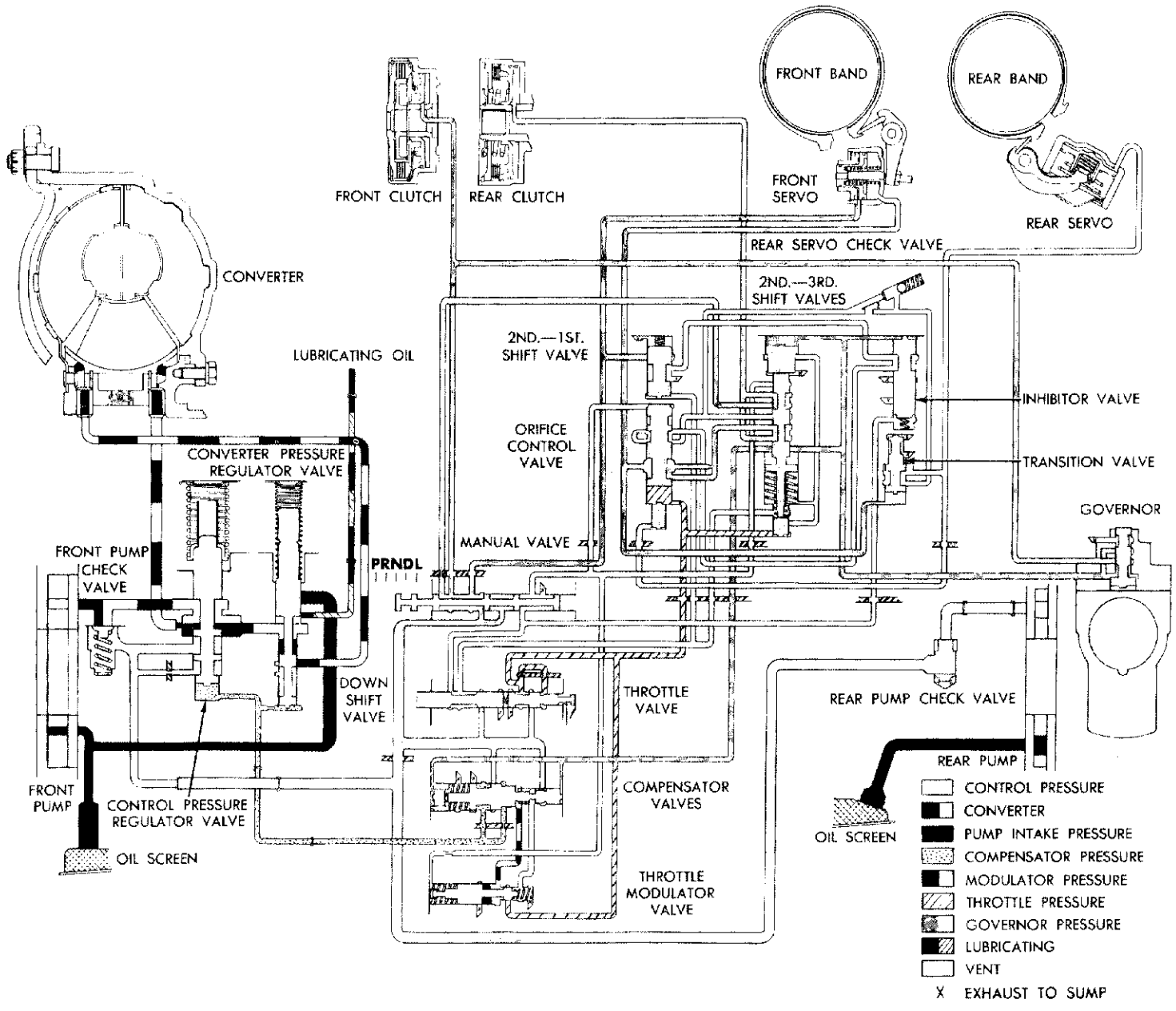
3. The apply side of the front servo
4. A land of the closed 2-1 shift valve

An additional passage is opened by the manual valve and pressure is directed to --

5. A land of the 2-3 shift valve.

With application of the front clutch (which drives the primary sun gear), and of the front band, (which holds the secondary sun gear), we have intermediate ratio.

Basic Hydraulic Circuit in Drive Range -- High Ratio (1955-1957 Models)



Basic Hydraulic Circuit in Drive Range -- High Ratio

With the selector in drive range, the shift from intermediate to high will take place at any speed between approximately 15 and 65 m.p.h. --depending on throttle opening.

When governor pressure, built up by road speed, is great enough to offset throttle pressure --

1. The 2-3 shift valve will move against its spring and throttle pressure, allowing control pressure to flow to --
2. The rear clutch and to --
3. The release side of the front servo releasing the front band.

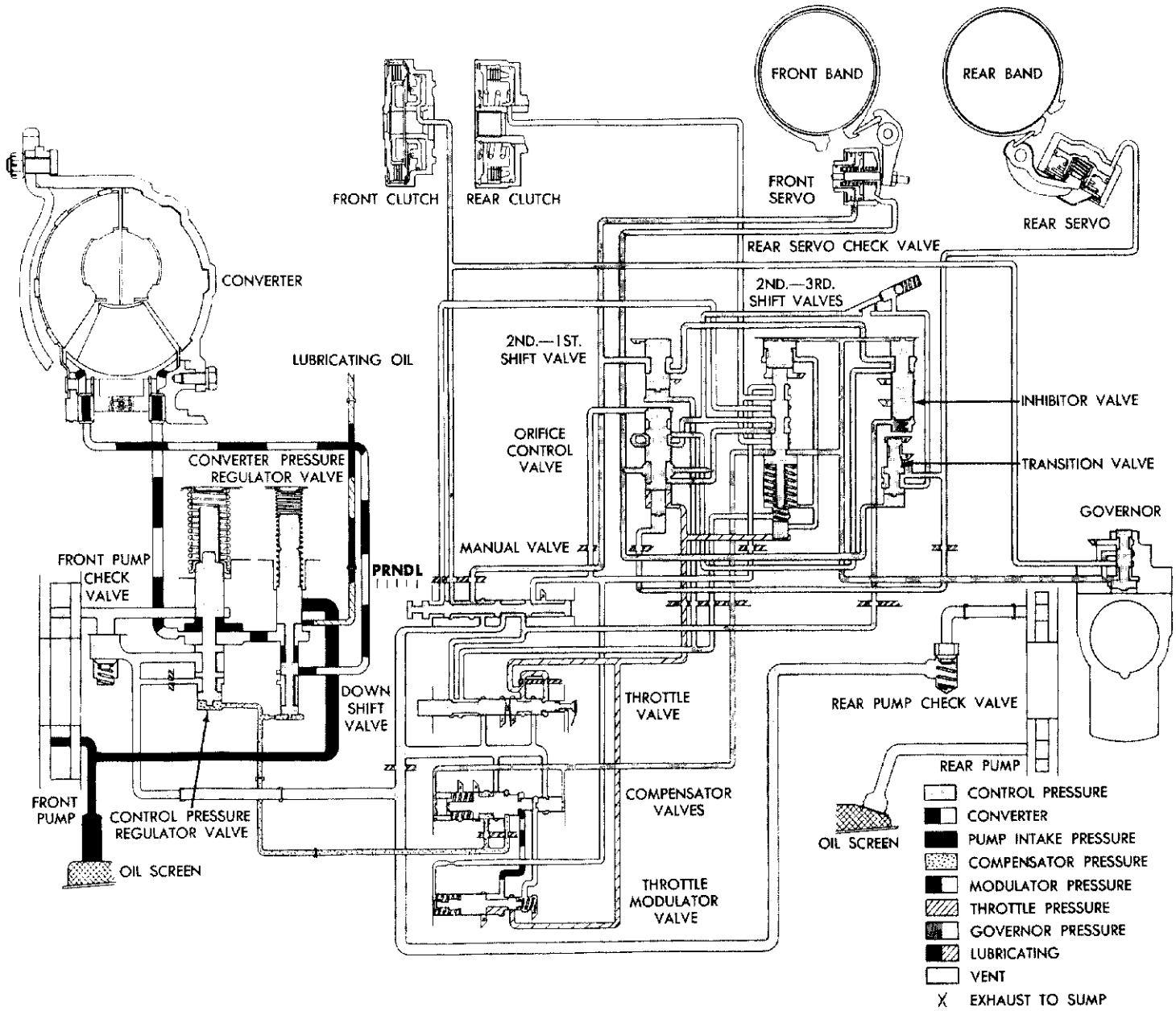
The control pressure directed to the release side of the front servo also flows --

4. Through the orifice control valve and to --
5. The large face of the transition valve.

With both clutches applied, and the front band released, the planetary unit is locked, and we are in high gear.

NOTE The front band is released by the application of the control pressure on the release side of the servo piston --which has a larger area than the apply side of the piston.

Basic Hydraulic Circuit with Selector in LO Position (1955-1957 Models)



A low ratio is provided for use in heavy going -- sand, snow, mud, when starting up on steep grades, or when braking action is desired in descending steep hills. Low ratio is obtained by moving the selector to the LO position. The transmission cannot upshift when the manual valve is in LO position. The following actions take place in this ratio:

With the manual control valve in the low position, control pressure is still directed to --

1. Front clutch
2. Governor

Control pressure is also directed through --

3. 2-1 shift valve
4. Valley of the inhibitor valve
5. Orifice control valve
6. To the valley of the transition valve.
7. And on up to apply the rear servo.

At the same time control pressure is directed through the --

8. 2-3 shift valve
9. Orifice control valve
10. To the large end of the transition valve.
11. And to the release side of the front servo.

Pressure coming from the valley of the transition valve is also directed to the plug end of the orifice control valve.

In addition, control pressure is directed from the manual valve through another passage to --

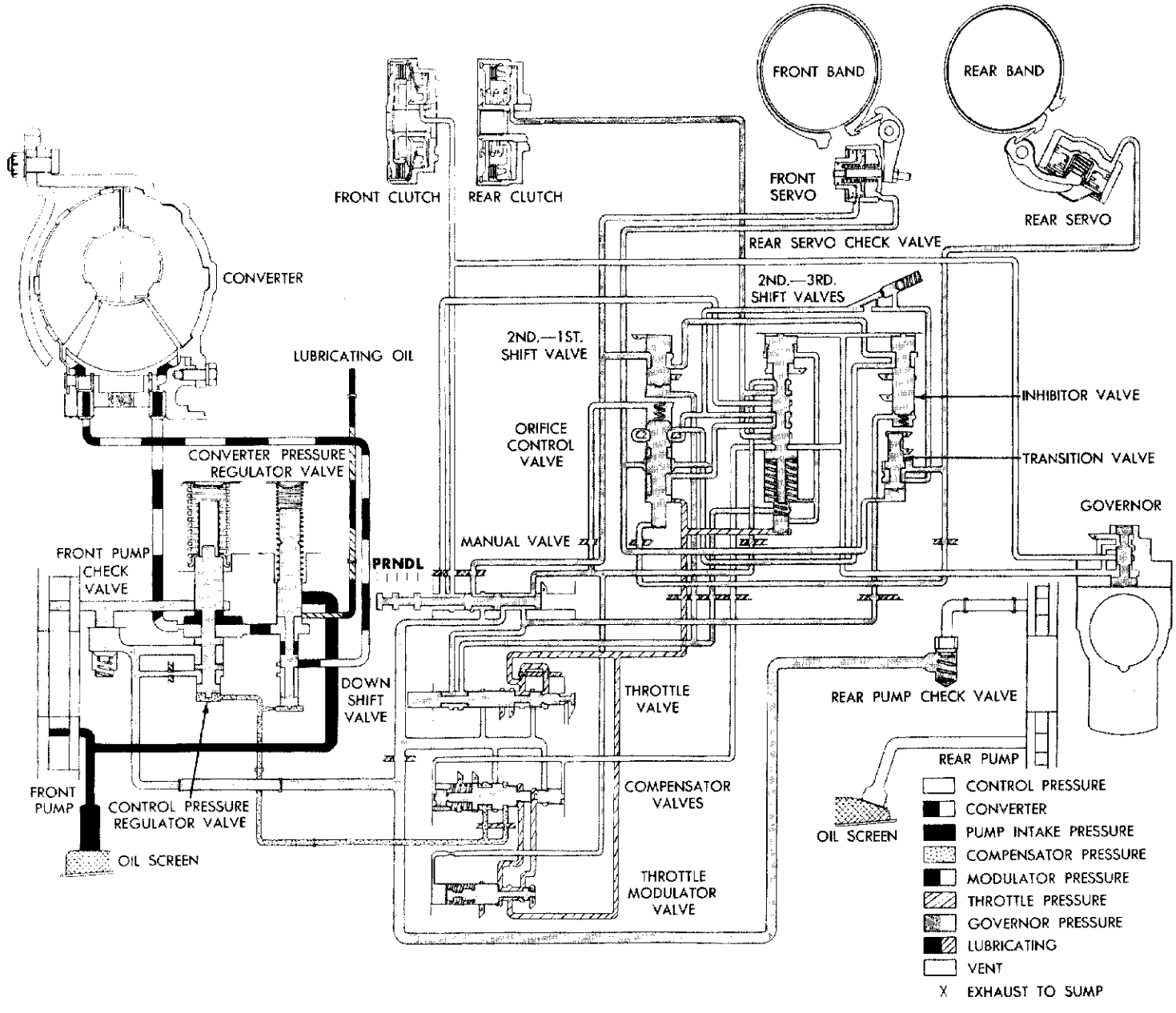
12. The spring end of the inhibitor valve and also through the valley of the --
13. Downshift valve to the
14. Spring end of the 2-3 shift valve and --
15. The end of the 2-1 shift valve.

Control pressure is also directed to the apply side of the front servo. Release pressure in the front servo overcomes the apply pressure because it is applied to a larger piston area. Therefore, the front band does not apply.

With the front clutch and rear band applied, we are in low.

NOTE Throttle and governor pressure only act through the compensator valve to vary control pressure in accordance with torque or operating conditions. Throttle pressure on the ends of orifice control valve and 2-3 shift valve holds them in such a position that throttle has no influence on them.

Basic Hydraulic Circuit in Reverse (1955-1957 Models)



Basic Hydraulic Circuit in Reverse

When the selector is moved to reverse position the following actions take place:

Control pressure to the front clutch and the governor is cut off at the manual valve. Control pressure is directed from the manual valve to the apply side of the front servo. Branching off from the same circuit, control pressure is directed to the rear servo through --

1. The 2-1 shift valve
2. The inhibitor valve
3. The orifice control valve
4. The transition valve.

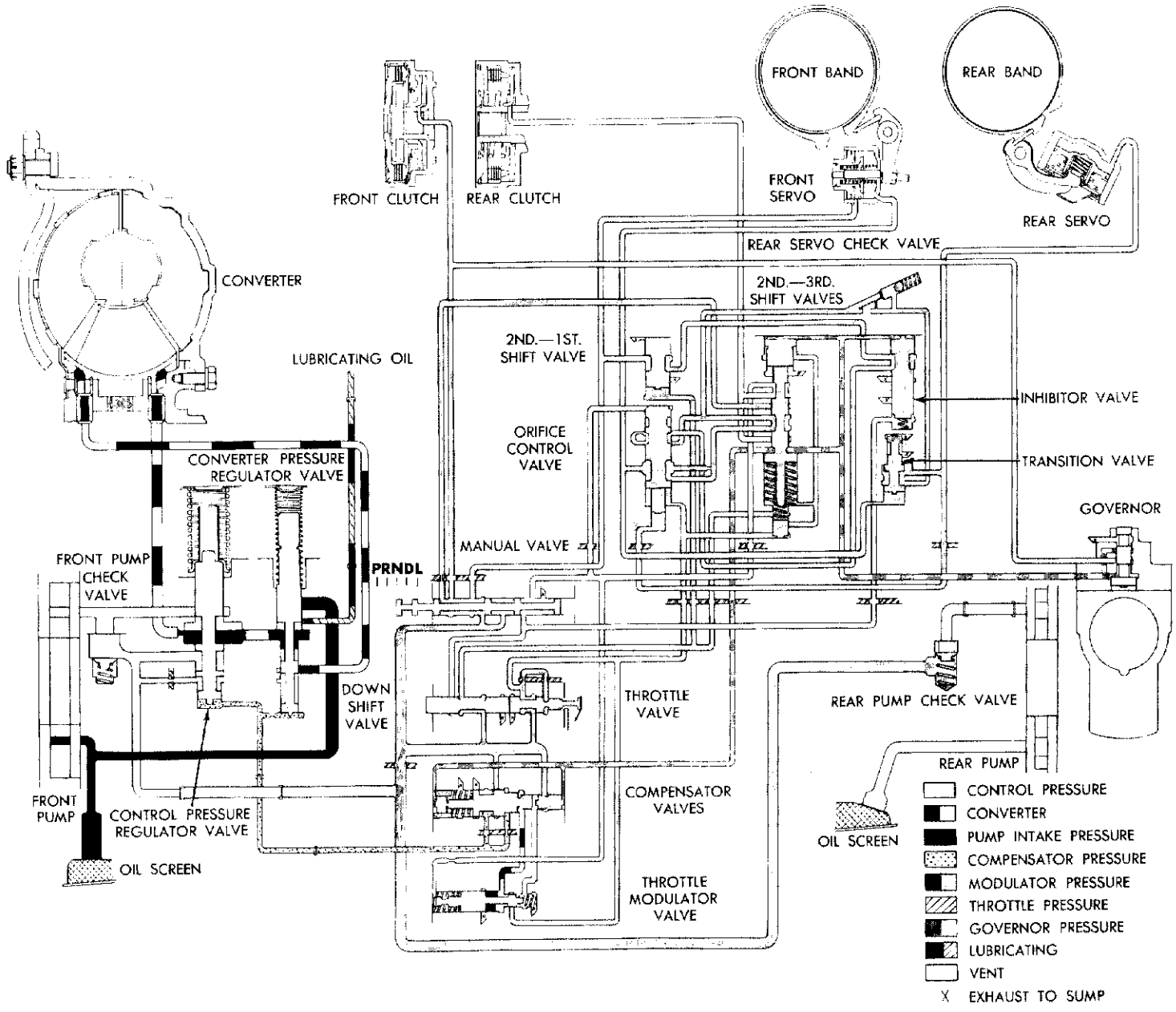
It also flows through --

5. The 2-3 shift valve
6. The orifice control valve
7. To the release side of the front servo.

This pressure is also directed to the ends of the transition and orifice control valves. Control pressure is directed through another passage from the manual control valve through the 2-3 shift valve to apply the rear clutch. The control pressure in this circuit is also directed to the spring end of the orifice control valve and the spring end of the throttle modulator valve.

Control pressure is directed through the downshift valve to the spring end of the 2-3 shift valve and the end of the 2-1 shift valve. The manual valve also directs pressure to the spring end of the inhibitor valve.

Basic Hydraulic Circuit -- 2-1 Kickdown in Drive Range (1955-1957 Models)



Basic Hydraulic Circuit 2-1 Kickdown in Drive Range

Controls after 1954 differ in operation from earlier controls, for they permit starts in low ratio to provide rapid acceleration with the selector in drive. This kickdown takes place when the accelerator is floored at speeds below 16 m.p.h. Then the automatic shift to intermediate occurs at about 30 m.p.h. With the selector in drive position, the manual valve is also in drive position, and now allows control pressure to flow through a common passage to --

1. The front clutch
2. The governor valve

The manual valve also directs pressure to --

3. The apply side of the front servo
4. A land of the closed 2-1 shift valve.

An additional passage is opened by the manual valve, and pressure is directed to --

5. A land of the 2-3 shift valve.

When making full throttle starts (through the detent), control pressure is directed through the open downshift valve to --

6. The end of the 2-1 shift valve (causing it to open).
7. The spring end of the 2-3 shift valve.

The control pressure from the downshift valve has opened the 2-1 shift valve allowing control pressure from the manual valve to apply the rear servo and release the front servo. The control pressure flows from the manual valve through --

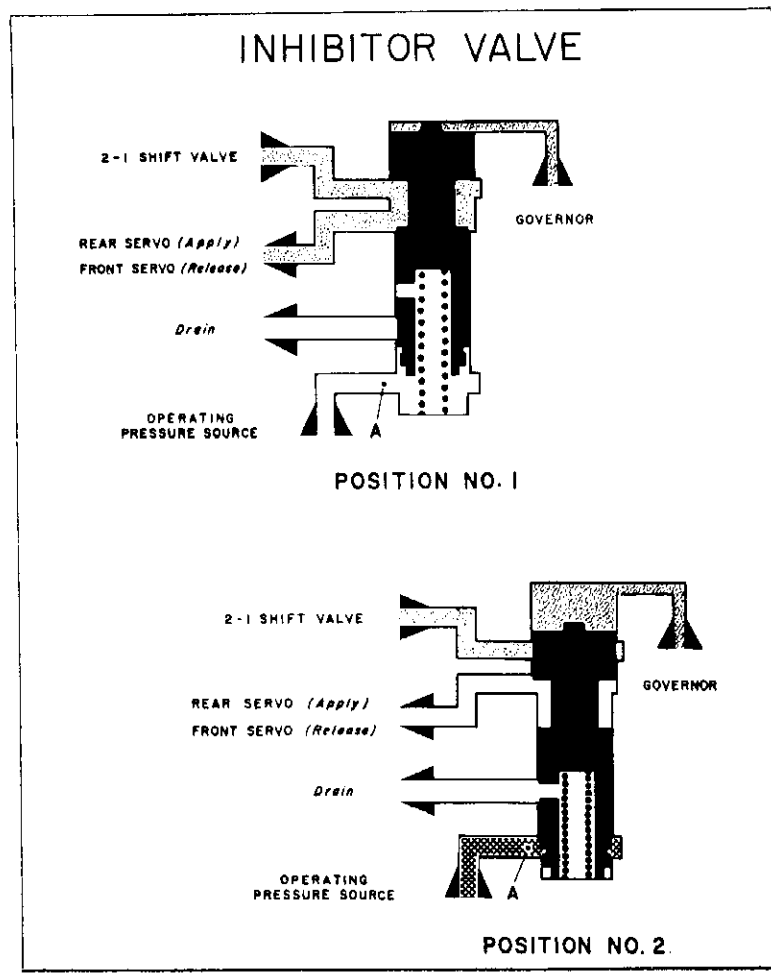
8. The open 2-1 shift valve
9. The inhibitor valve
10. The orifice control valve
11. The transition valve
12. To the rear servo.

Control pressure also flows through the open transition valve to the rear servo. The rear servo apply pressure also flows to the plug end of the orifice control valve. With the front clutch and band applied LO is realized.

When speeds of approximately 30 m.p.h. are reached, governor pressure acting on the inhibitor valve will overcome the inhibitor valve spring. This cuts off the control pressure that is applied to the rear servo and release side of the front servo.

This pressure also flows to the --

13. 2-3 shift valve
14. Through the orifice control valve
15. To the release side of the front servo.
16. And to the large end of the transition valve.

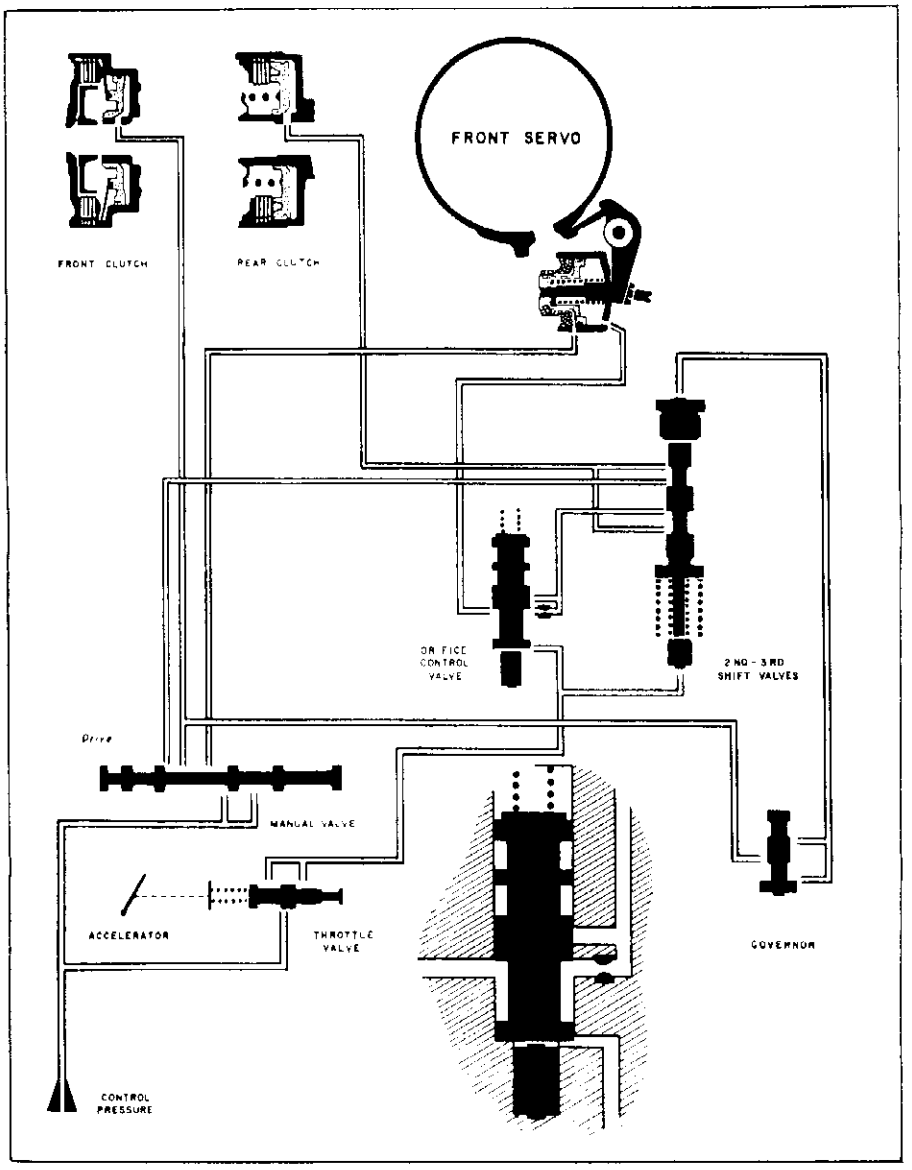


DR (Drive) to LO Shift of Selector

If, at road speeds below approximately 25 m.p.h. the selector lever is moved from drive range to LO, the transmission will shift immediately to low ratio. At higher speeds, this is prevented by the inhibitor valve to avoid damage to the transmission.

1. Position No. 1 shows the inhibitor valve as the car starts up in any range. In low and reverse ranges, control pressure, applied at "A", prevents any further action of the valve. In drive range, the valve closes the rear servo apply passage when the governor builds up the necessary pressure.

2. Position No. 2 shows the valve when the selector lever is in low range and car road speed is above 25 m.p.h. The pressure coming from the 2-1 shift valve is blocked by the inhibitor valve land. The operating pressure from the manual valve can act only on a small area of the end of the inhibitor valve. This force helps the spring move the valve against governor pressure when road speed has dropped to about 25 m.p.h. When the valve moves enough to close the drain port and allow line pressure to get behind it, the remainder of its travel is fast and positive.

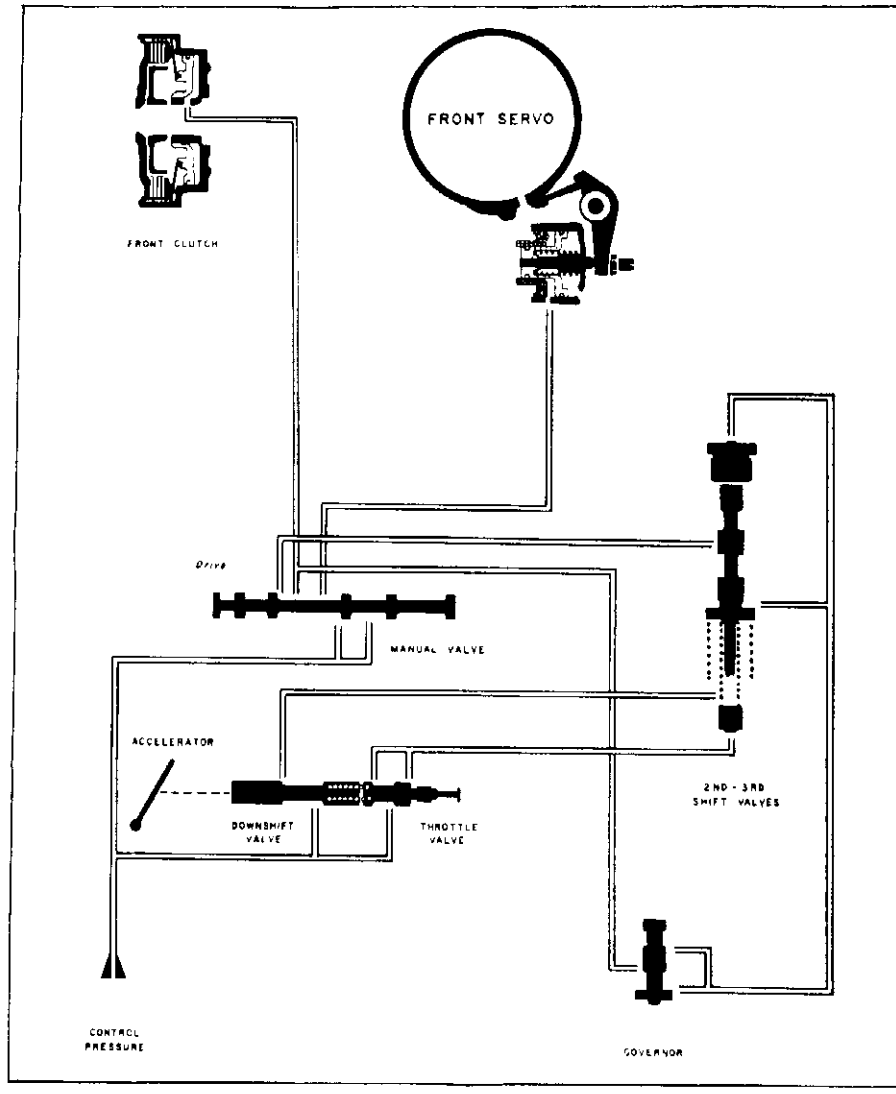


Basic Hydraulic Circuit During Normal 3-2 Downshifts

The closed throttle 3-2 downshift occurs when road speed drops to a point where governor pressure can't hold the shift valve open. Under these conditions, the following actions take place:

1. The shift valve spring closes the valve. This exhausts rear clutch apply and front servo release fluid.

2. The apply pressure, still present in the front servo, applies the front band. Application of this band is cushioned by the orifice control valve which causes the front servo release fluid to exhaust through a small orifice with the throttle closed. This places the transmission in intermediate ratio.



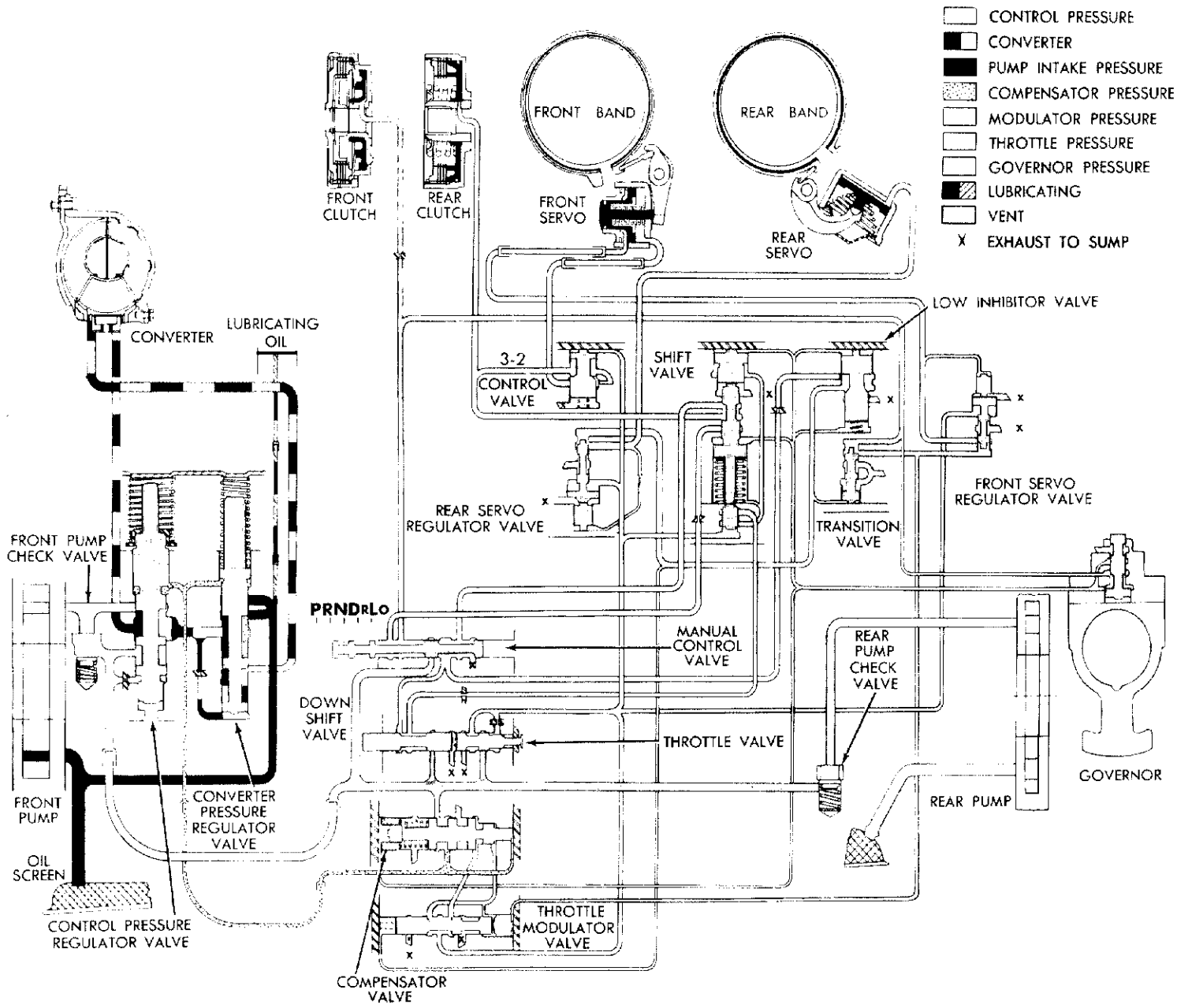
Basic Hydraulic Circuit During Forced 3-2 Downshift

When the transmission is in high ratio at road speeds below approximately 55 m.p.h., a 3-2 shift is possible by pushing the accelerator pedal to the floor board.

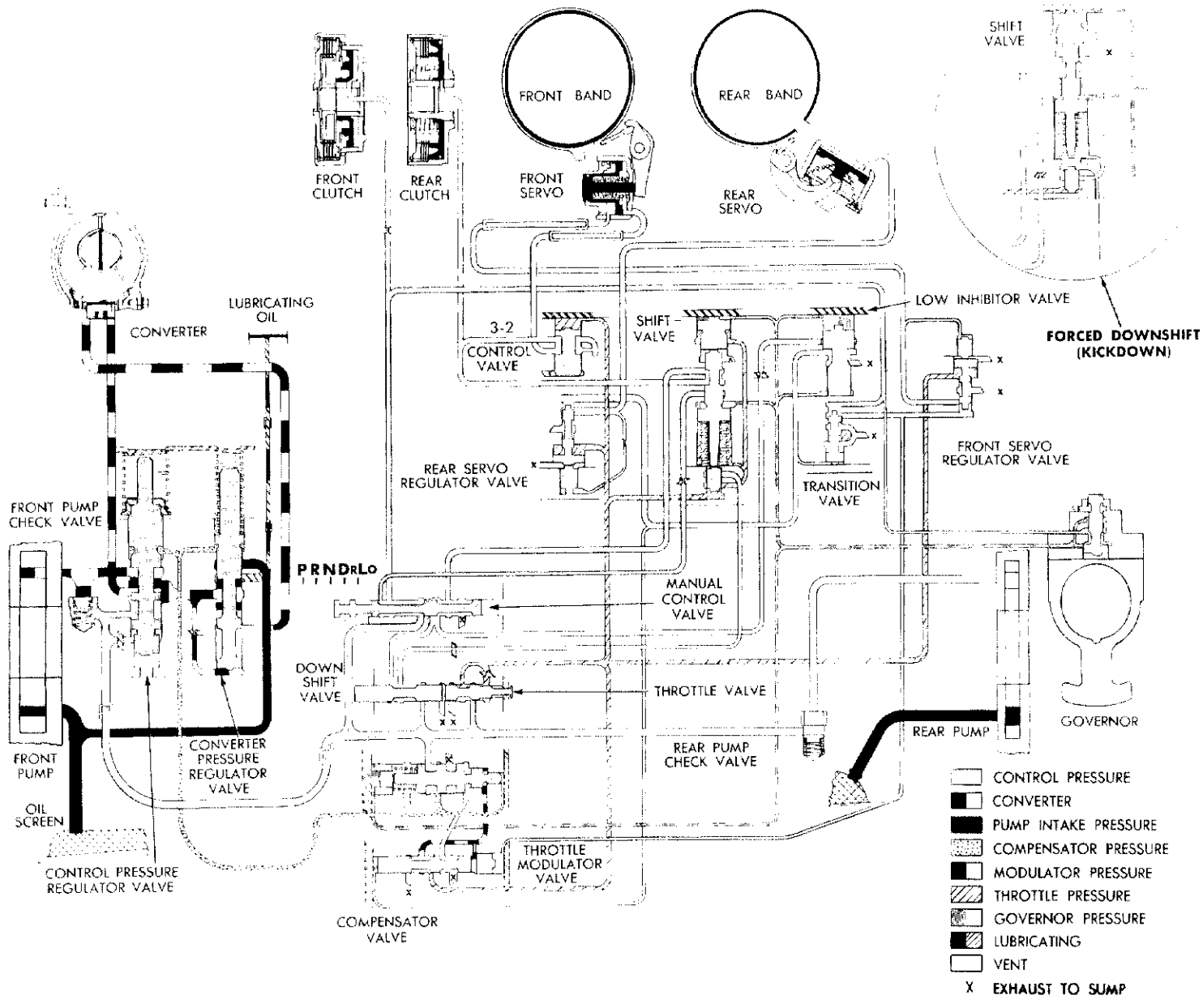
1. Under these conditions, governor pressure, higher than the combined force of the shift valve spring and throttle pressure, holds the shift valve open. To close the shift valve and place the transmission in intermediate ratio an additional force must be provided to assist the spring and throttle pressure.

2. To provide this assisting force, the downshift valve directs control pressure to the spring side of the shift valve. (At the same time, throttle pressure positions the orifice control valve so that fluid from the release side of the front servo is rapidly exhausted. This allows quick application of the front band.) The front band is applied as the rear clutch is released, changing the ratio from high to intermediate.

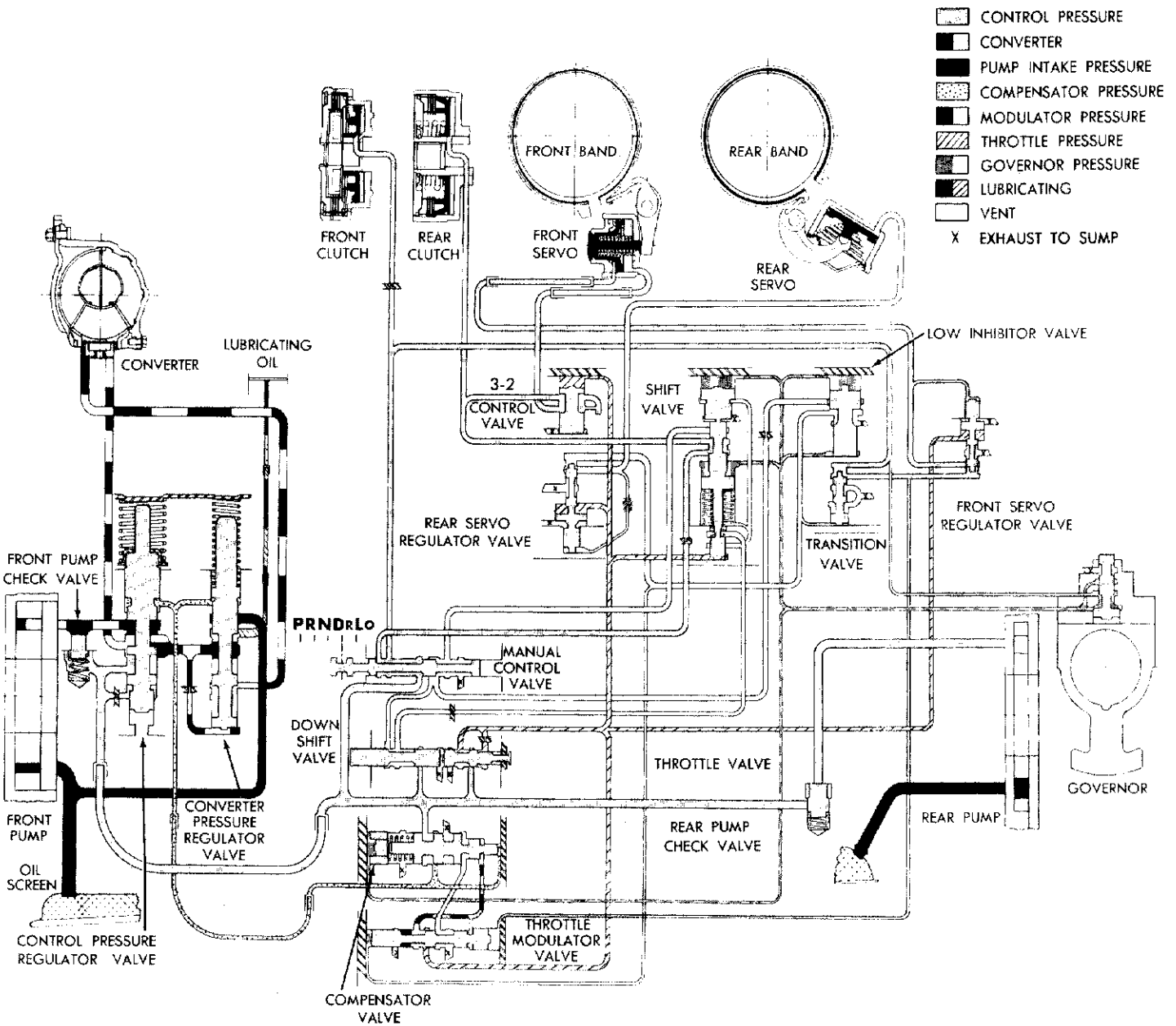
Hydraulic System in Neutral (1951-1954 Models)



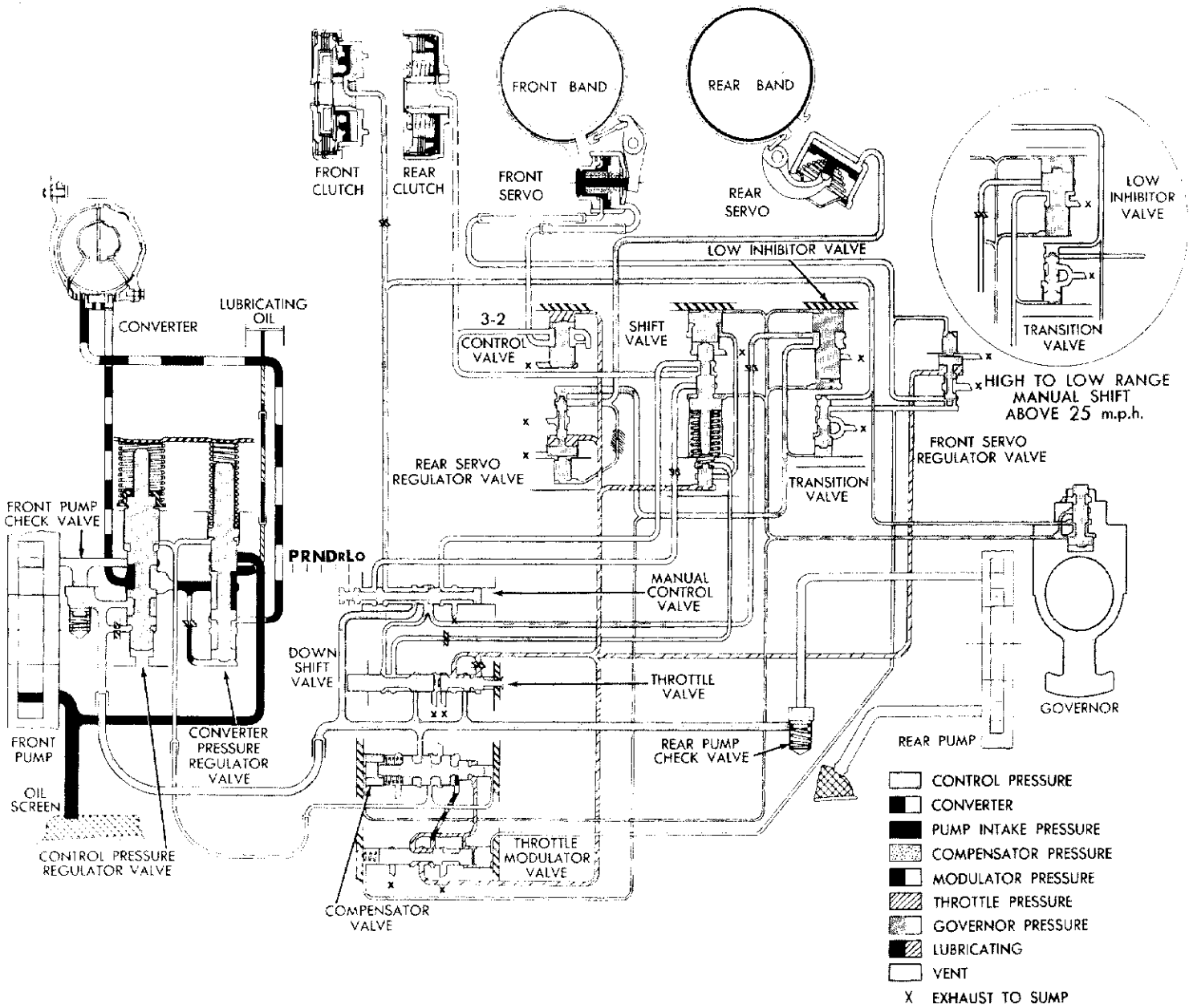
Hydraulic System in Drive Range -- Intermediate Ratio (1951-1954 Models)



Hydraulic System in Drive Range -- High Ratio (1951-1954 Models)



Hydraulic System with Selector in LO Position (1951–1954 Models)



Hydraulic System in Reverse (1951-1954 Models)