TRAINING HANDBOOK

COURSE
7500.5
7501.4

the C6 Automatic Transmission

- ✔ PRINCIPLES OF OPERATION
- ✔ DIAGNOSIS AND ADJUSTMENT

SERVICE FORD MOTOR COMPANY TRAINING

FORD DIVISION

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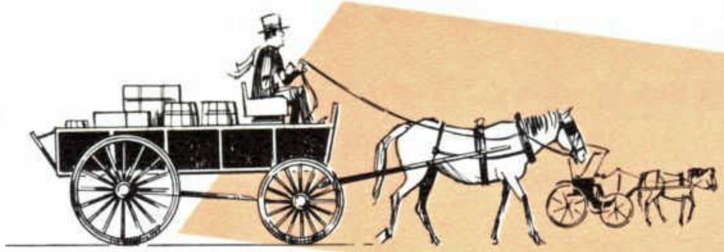


HORSES AND COMPUTERS

And **you** are the connecting link.

You know, it hasn't been so long ago that all our vehicles were horse-drawn instead of motor-driven.

Service was a pretty simple matter in those days. Buggies just weren't very complicated, and when something broke down, it was no trouble to find out what it was.

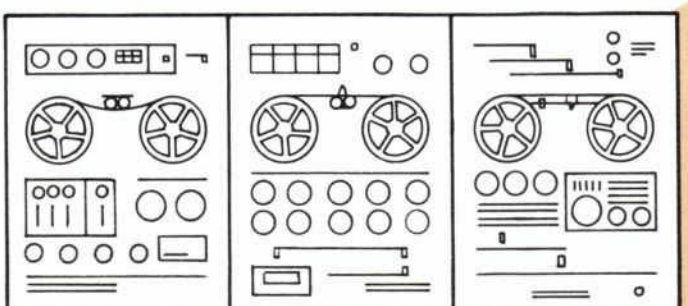
Then came the motor car—first a pretty simple adaptation of a buggy—but today an exceedingly sophisticated mechanism. A machine, in fact, that takes highly trained, skilled technicians (like you) to diagnose troubles in components like automatic transmissions that are as complicated as computers. If you think about it a minute, a fully automatic transmission like the C6 actually **is** a computer, since it digests road speed and engine load signals and automatically adjusts to the best gear ratio for the driving conditions.

Well, in today's era of automation, it really isn't too hard to envision a time when it will be possible to hook up another computer to an ailing automatic transmission, push the "what's wrong?" button, and get a little instant diagnosis. But until such a machine is available, there's no substitute for technical service knowledge, and for a commodity that's carried over from an earlier era—a commodity most good automatic transmission technicians seem to have a good supply of—namely, horse sense.

Matter of fact, you don't really have to be a whiz at following fluid flow paths or power flow diagrams to do a good job of automatic transmission diagnosis.

- If you'll take the trouble to learn generally how the transmission works, and
- If you'll follow the recommended test and adjustment procedure, and
- If you'll use your thinker a little and apply some of that good horse sense—

—Well, you'll find that a lot of troubles will disappear just from making the adjustments. And when the adjustments don't cure the trouble, most times you'll be pretty certain about where the trouble is—and you'll often be able to fix it without overhauling the transmission.



INTRODUCTION

Learning the C6 automatic transmission should be no problem for you if you're familiar with other Ford automatics. Like those that have gone before, the C6 is a fully automatic three-speed transmission, with the same driving ranges as other Cruise-O-Matics.

As you can see in Fig. 1, the C6 consists essentially of a torque converter; a compound planetary gear train controlled by one band, three disc clutches and a one-way clutch; and a hydraulic control system. The three systems are treated individually in this handbook.

RESEMBLES C4

The C6 most closely resembles the C4 Cruise-O-Matic, which was introduced in 1964. Of course, the C6 is a larger version of this design for higher torque engines.

The gear trains are of the same design, and so are the clutch and band combinations with one exception. The C6 has a low-and-reverse clutch in place of the C4 low-and-reverse band.

In the hydraulic control system, the principal valves perform identical functions, though there are some minor differences in design. Also, you'll find some new valves in the C6 that are used to ensure good shift quality.

OPERATION

The C6 has the standard Cruise-O-Matic shift selector (Fig. 2) with six positions—Park, Reverse, Neutral, D2 (small dot), D1 (circle), and Manual Low.

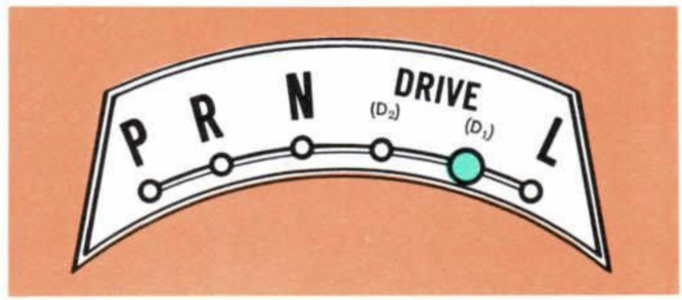


Fig. 2—Automatic Transmission Selector

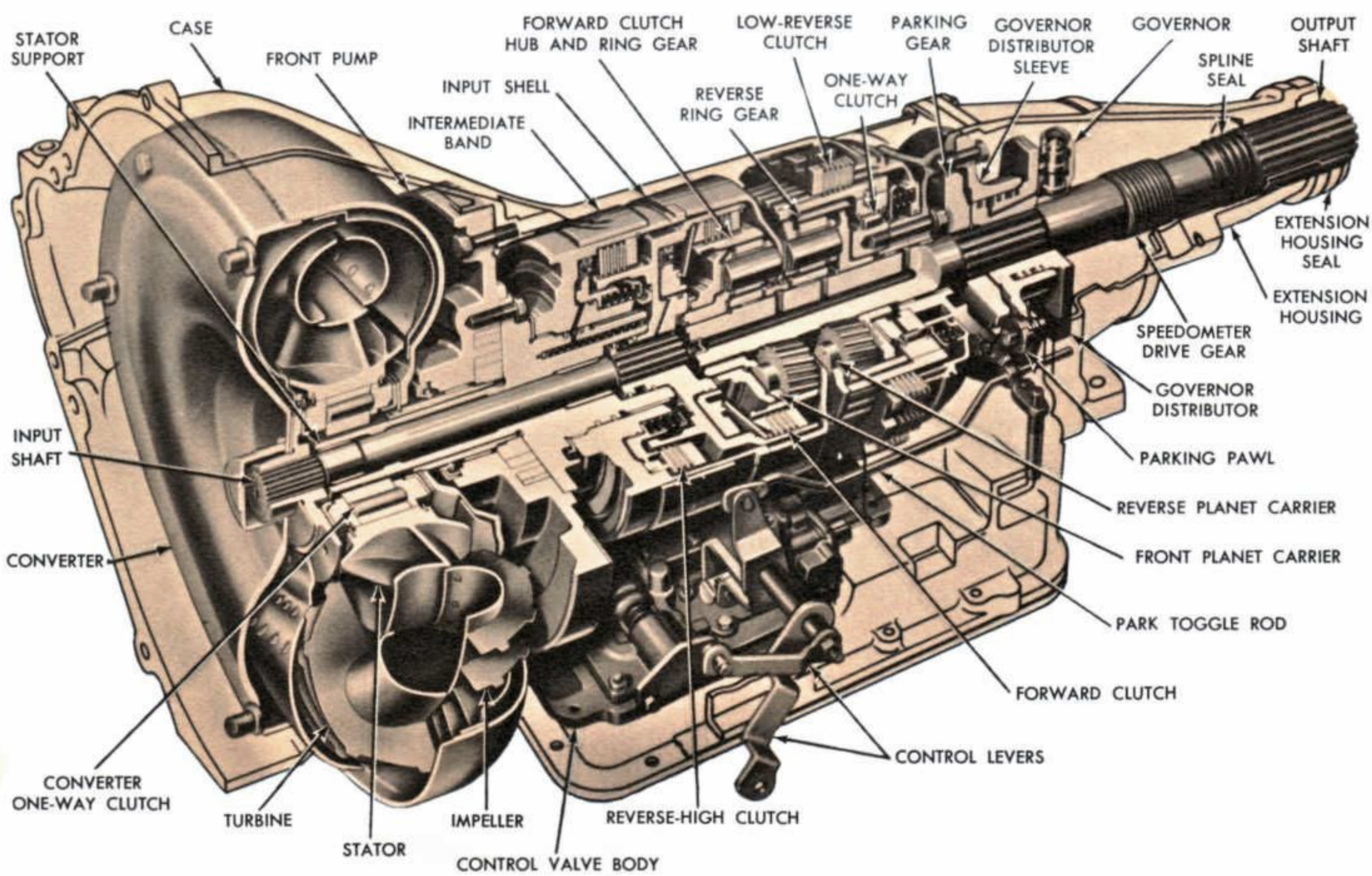


Fig. 1—C6 Transmission

In the normal driving range (D1), the car starts in low gear, with automatic upshifts to second and high as road speed increases. With the throttle closed, the transmission downshifts from high to low in D1 at about 10 mph.

D2 range provides a second gear start and upshift to high. The coasting or closed-throttle downshift to second gear occurs at about 10 mph.

Manual low (L) range is designed primarily for engine braking. Starting in this position, the car is in low gear and there is no upshift. If the transmission is in high gear in D2 or D1 and the driver moves the selector lever to L, a downshift to **second** occurs, and the transmission stays in second down to 10 mph. Then it downshifts to low.

PARKING PAWL

The transmission gear train is in neutral in both the P and N positions. There is no pressure to any clutch and only the transmission input shaft turns. In park, a pawl engages a parking gear which is splined to the transmission output shaft (Fig. 1) to lock the rear wheels to the transmission main case.

A neutral start switch mounted on the transmission and operated by the selector linkage completes the engine cranking circuit in P and N only so that the engine can't be started in any drive gear.

FORCED DOWNSHIFTS

Forced downshifts (kickdown shifts) from high to second gear are possible at speeds as high as 65 mph in D1 or D2. In D1, it is possible to force a downshift to first gear up to 30 mph.

The carburetor is at full throttle before the accelerator is floor-boarded. Up to full throttle, a "torque demand" downshift to second is possible up to 40 mph. "Kickdown" shifts require depressing the accelerator to the floor to actuate the downshift valve in the transmission.

GEAR RATIOS

Engine torque is multiplied in the transmission by both the torque converter and the planetary gear system as driving conditions demand.

At stall (engine operating, transmission in gear, but car stopped), the torque converter provides multiplication up to 2.1 to 1. The transmission gear ratio then is multiplied by 2.1 to determine the total torque multiplication available. This figures out to:

GEAR	PLANETARY GEAR RATIO	TOTAL REDUCTION WITH CONVERTER
First (Low)	2.46 to 1	5.17 to 1
Second (Intermediate)	1.46 to 1	3.07 to 1
Third (High)	1.00 to 1	
Reverse	2.175 to 1	4.27 to 1

USING THIS HANDBOOK

This handbook has been prepared so that a technician with no knowledge of automatics can learn the C6 operation by reading the following sections and studying the diagrams. There is a glossary of technical terms used in the copy at the end of the book, which can be used for reference during the study.

If you are already an experienced automatic transmission man and understand the operation of automatics well (particularly the C4), a quick reading of some sections will do for you. You should put your greatest study emphasis on the control valve section where the most significant changes are. Of course, in any case, be sure to keep this handbook for reference after you finish studying the C6 automatic transmission.

TORQUE CONVERTER

The C6 torque converter (Fig. 3) is typical of converters used in other Ford automatics. It consists of an **impeller** or pump, the driving member; a **turbine,** the driven member; and a **stator** or stationary member—all in a welded housing. The impeller forms the rear section of the housing and the converter covers the front section.

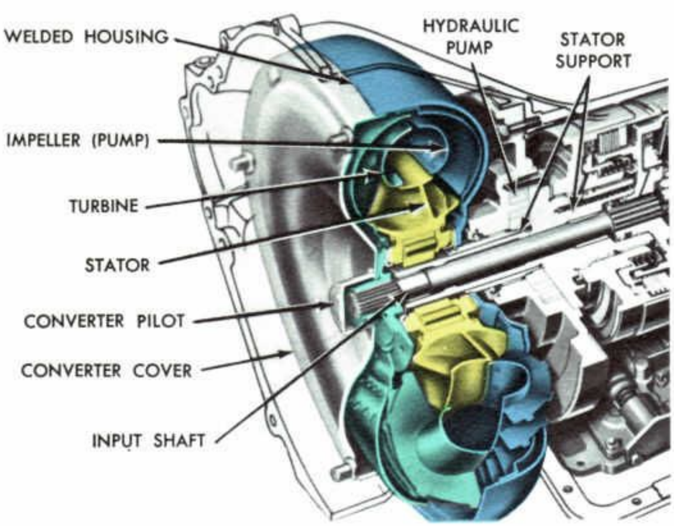


Fig. 3—Torque Converter

STATOR SUPPORT

The converter is supported by the pump housing and by the engine crankshaft. Studs in the cover fasten it to a driving plate attached to the crankshaft, and a pilot hub mates with a bore at the center of the crankshaft. The converter assembly serves as the engine flywheel. The rear hub of the impeller housing pilots in the transmission pump, and flats on the hub drive the pump whenever the engine is turning.

HYDRAULIC CLUTCH

There is no mechanical connection between the impeller and the turbine, which is splined to the transmission input shaft. The converter acts as an automatic clutch with the engine driving the impeller mechanically, the impeller driving the turbine hydraulically and the turbine driving the gear train mechanically. There is no neutral or disengaged clutch position in the converter. The only neutral is in the gear train.

IMPELLER PUMPS FLUID

The purpose of the impeller is the same as any

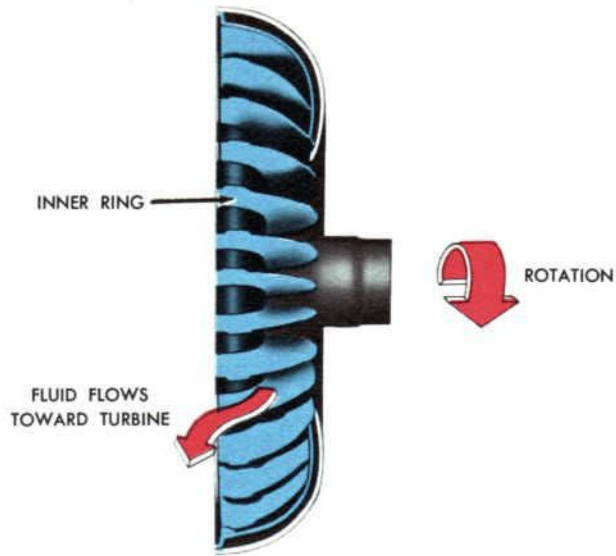


Fig. 4—Impeller Operation

pump—to put the fluid in motion. Inside the impeller housing (Fig. 4), many curved vanes, along with an inner ring, form passages for the fluid to flow through. The rotating impeller acts very much like a centrifugal pump. Fluid is supplied by the hydraulic control system, and flows into the passages between the vanes. When the impeller turns, the vanes accelerate the fluid and centrifugal force pushes the fluid outward so that it is discharged from openings around the inner ring. The curvature of the impeller vanes directs the fluid toward the turbine, and in the same direction as impeller rotation.

FORCE ON TURBINE

The vanes in the turbine are curved opposite to the impeller, and the impact of the moving fluid on the turbine vanes (Fig. 5) exerts a force that tends to turn the turbine in the same direction as impeller rotation. When this force creates a great enough torque on the transmission input (turbine output) shaft to overcome the resistance to motion, the turbine begins to rotate.

Now the impeller and turbine are acting as a simple fluid coupling, but we have no torque multiplication yet. To get torque multiplication, we must return the fluid from the turbine to the impeller and accelerate the fluid again to increase its force on the turbine.

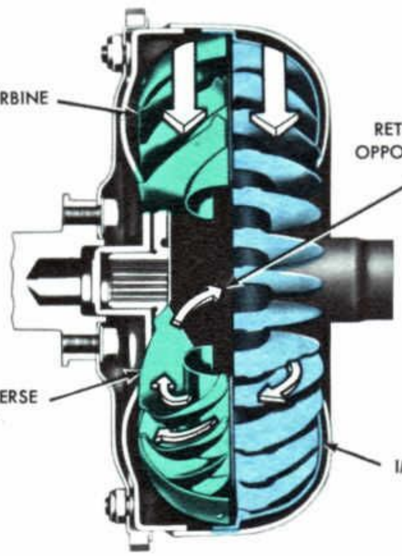


Fig. 5—Fluid Coupling

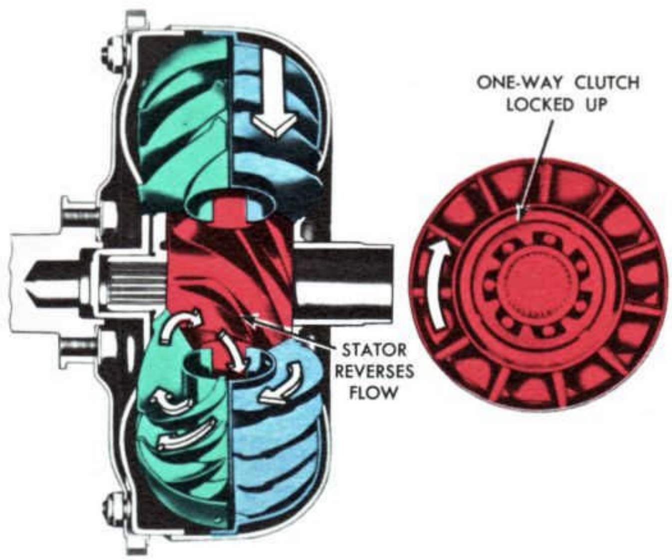


Fig. 6—Vortex Flow

REVERSING THE FLOW

To get maximum force on the turbine vanes when the moving fluid strikes them, the vanes are curved to reverse the direction of flow (Fig. 5). Less force would be obtained if the turbine deflected the fluid instead of reversing it. At any **stall** condition, that is, with the transmission in gear and the engine operating, but the turbine standing still, the fluid is reversed by the turbine vanes and pointed back to the impeller. You can see, that without the stator, any momentum left in the fluid after it leaves the turbine would resist the rotation of the impeller.

STATOR AND ONE-WAY CLUTCH

The stator reverses the fluid again (Fig. 6) and returns it to the impeller in the direction of impeller rotation. A one-way clutch prevents the force of this fluid from turning the stator opposite the impeller and turbine.

As the fluid flows from the stator to the impeller, the impeller has another opportunity to accelerate the same fluid, and it does so. The fluid leaves the impeller with perhaps twice the energy it had the first time, and exerts a greater force on the turbine.

VORTEX FLOW

We call the flow of fluid through the impeller, to the turbine, to the stator, and back through the impeller, the **vortex flow.** At high impeller speed and low turbine speed, the vortex flow velocity is the sum of the impeller produced velocity, plus the velocity of the fluid returning from the turbine and stator. It is vortex flow that gives us torque multiplication.

TORQUE MULTIPLICATION

By torque multiplication, we mean that there is more torque on the turbine shaft than the engine is putting out—because the vortex fluid is accelerated more than once. Torque multiplication is obtained at the sacrifice of turbine rotation. Actually, it's no different from mechanical advantage which you get from gearing down. You gain torque by sacrificing motion.

Torque multiplication takes place anytime the turbine is turning at less than $\frac{9}{10}$ impeller speed. At full stall, the C6 converter produces a 2.1 to 1 torque multiplication. As the turbine speed increases in relation to the impeller, torque multiplication decreases.

ROTARY FLOW

Vortex flow is not the only fluid force trying to turn the turbine. The vortex flow leaving the impeller is not only flowing out of the impeller at high speed, but it is also rotating faster than the turbine. As this rotating fluid strikes the slower turning or stationary turbine, it exerts a turning force against the turbine. This is referred to as the **rotary flow.**

COUPLING PHASE

When the coupling phase is reached—that is, when the turbine speed is about $\frac{9}{10}$ impeller speed—there is no longer any torque multiplication. The converter then is simply transmitting engine torque to the gear train.

As the turbine begins to rotate and steadily picks up speed, the vortex flow steadily loses speed because of the increasing centrifugal force acting against the flow through the turbine. The rotating impeller produced a centrifugal force in the fluid which caused it to flow from the center outward. The same centrifugal force is acting in the rotating turbine, trying to prevent the fluid from flowing inward. As the vortex flow slows down, torque multiplication is reduced.

ONE-WAY CLUTCH UNLOCKS

As the turbine catches up with the impeller, the angle at which the fluid leaves the turbine is constantly changing (Fig. 7), due to centrifugal force and to the turbine absorbing more of the energy of

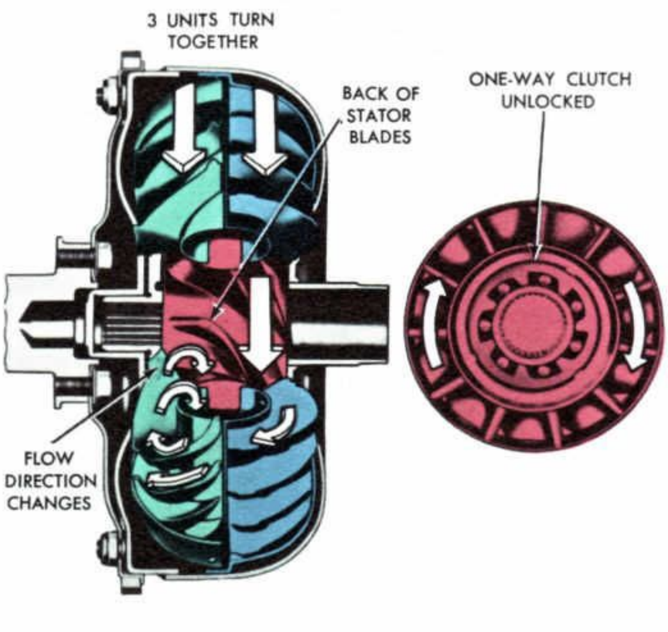


Fig. 7—Coupling Phase

the moving fluid. In the coupling phase, the fluid leaving the turbine strikes the **backs** of the stator vanes. The one-way clutch unlocks then and the impeller, turbine and stator turn together.

AUTOMATICALLY ADJUSTS TORQUE

Let's discuss some aspects of the converter that we may have missed. Since vortex flow speed is governed by the difference between impeller and turbine speed, the torque converter automatically adjusts converter output to drive shaft torque requirements.

When the drive shaft torque requirements become greater than the engine output torque, the turbine slows down and causes an increase in vortex flow velocity and thereby, an increase in torque multiplication. This automatic adjustment between torque input and output permits the converter to absorb the shock of sudden ratio changes (gear shifts) in the planetary gearset, especially at the lower road speeds.

If we are driving a C6 Automatic and cruising at 20 mph in high gear, then suddenly depress the accelerator pedal to less than a full-throttle downshift position, we hear the engine speed increase rapidly, while the road speed will increase somewhat slower. In this case, it is not entirely accurate to say that the converter is slipping. (There is, of course, some slippage in the converter at all times.) It is more accurate, in this instance, to say that the torque converter has automatically adjusted itself to produce a greater engine torque multiplication to increase drive shaft speed. Torque multiplication can occur in the converter only when the turbine rotates at less than $\frac{9}{10}$ impeller speed.

When the converter is in multiplication, the recirculating vortex flow causes heat to be generated. To keep the fluid from overheating, a constant flow of fluid into and out of the converter is maintained. The fluid coming out of the converter is forced through a cooler located in the radiator tank.

In summary, the torque converter automatically performs the following functions:

- Acts as an automatic clutch. At engine idle speed, it permits the engine to operate and the car to stand still.
- Adjusts, within its design limits, engine input torque to drive shaft torque requirements.
- Absorbs the shock of gear ratio changes (shifts).

PLANETARY GEAR SYSTEM

The C6 transmission uses a compound planetary gearset with one band, three friction clutches and a one-way clutch to provide the three speeds forward and one reverse. Before we see exactly how this system is put together and operates, let's review the operating principles of planetary gears.

PLANETARY GEAR PRINCIPLES

THE SUN AND THE PLANETS

A simple planetary gearset (Fig. 8) consists of an internal gear or **ring gear,** a **sun gear,** and a number of **planet pinions.** The planet pinions are mounted on shafts or pins on a **planet pinion carrier.** Thus, the pinions can rotate on their own axes, and also

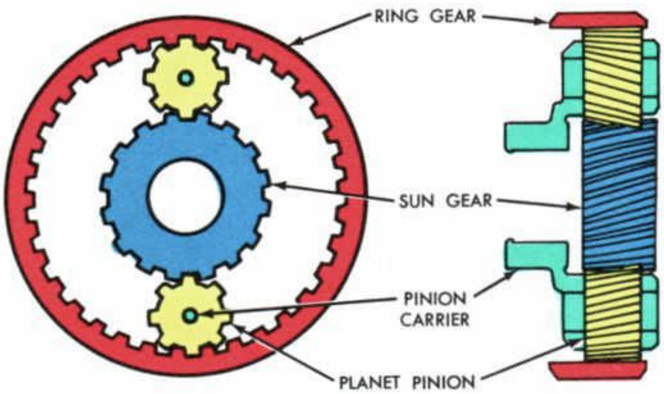


Fig. 8—Planetary Gearset

can revolve about the sun gear if the pinion carrier is free to turn. The gearset and its parts get their name from their parallel with the sun and the planets.

ALWAYS IN MESH

One thing that's immediately evident about this gearset is that the gears are always in mesh. You can also see that unlike the spur gears in a manual-shift transmission, planetary gears are not subject to high side loads when they're under torque. Also, we have many more teeth working at any time in a planetary gearset. What this all adds up to is that the driver doesn't have to be nervous about doing a lot of driving in the lower gears—such as in stop and start traffic or using first gear for down-hill braking.

GEAR COMBINATIONS

With a single planetary gearset, we have a number of possible gear combinations. These are:

- DIRECT DRIVE
- REDUCTION
- REVERSE
- NEUTRAL
- OVERDRIVE

We'll encounter all these combinations in the C6 except overdrive. As a matter of interest, though, with all the reduction we get in the C6 transmission and with a high-speed rear axle, we actually get all the benefits of overdrive along with automatic shift. At cruising speed in high gear, the engine is turning at about the same rpm it would with overdrive.

DIRECT DRIVE

Direct drive is accomplished in the planetary gearset by locking any two members together (Fig. 9). Then, no matter which member is driven, the complete set turns as a unit. If, for example, our pinion carrier is splined to an output shaft, and the ring gear and sun gear are locked together and driven by an input shaft, we have a direct drive through the gearset, with output through the pinion carrier.

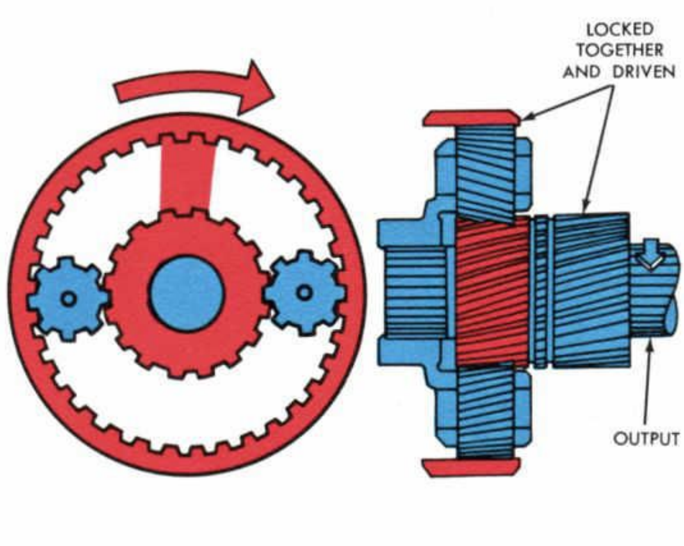


Fig. 9—Direct Drive

REDUCTION

One way to obtain reduction in a planetary gearset is to hold the sun gear and drive the ring gear with the planet carrier as the output member (Fig. 10). Rotation of the ring gear makes the planet pinions "walk" around the sun gear, in the same direction the ring gear is turning, but not as fast. Input torque is increased or multiplied since output speed is less than input.

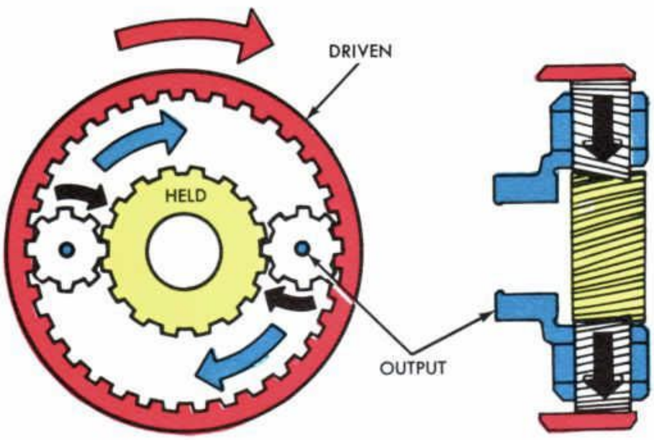


Fig. 10—Reduction

REVERSE

In a simple planetary gearset, we get a reverse output anytime we hold the planet pinion carrier and drive another member. The planet pinions just turn on their axes then and act as idler gears—reversing the direction of the input.

For instance, if we drive the sun gear clockwise with the pinion carrier held (Fig. 11), the pinions turn counterclockwise and cause the ring gear also to turn counterclockwise.

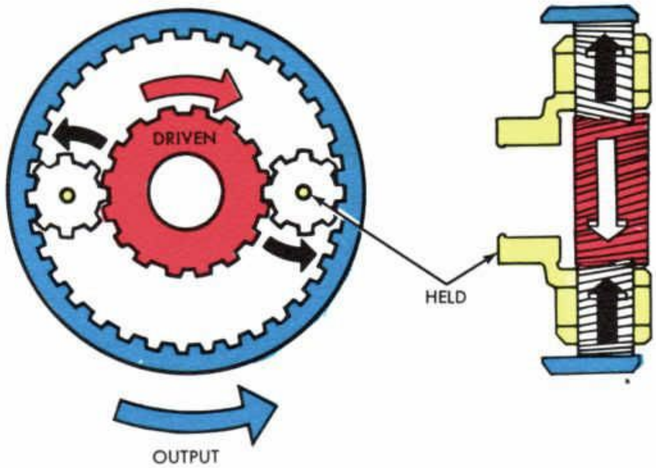


Fig. 11—Reverse

CLUTCHES AND BANDS

To lock planetary gearset members together, we use hydraulically applied multiple-disc clutches. To hold a member from turning, we use multiple-disc clutches, bands or overrunning clutches. We'll go over the operation of the C6 band and clutches as we go through a gear train buildup now.

C6 GEAR TRAIN BUILDUP

The difficulty with demonstrating and observing the operation of the C6 gear train is that with the parts assembled most of the gears are hidden by drums or the input shell. Other than using transparent gears, the only way to see the gear and clutch action is with partly sectioned drawings. To make it easy to read these sectioned drawings, we'll build up the gear train piece-by-piece. In the buildup, you can examine the construction of each piece and its connection and relation to the other pieces. Keep in mind that this buildup is for instruction only and has no relation to the assembly or disassembly order.

INPUT SHAFT

The input shaft (Fig. 12) is supported by two bushings in the stator support. End play in the input shaft is controlled by the front splines bottoming in the converter turbine hub and in the hub of the forward clutch cylinder.

OUTPUT SHAFT

The output shaft (Fig. 12) is supported by a bushing in the case and by the slip-yoke bushing in the extension housing. End play control will come up later in the buildup. Of course, the output shaft never touches the input shaft.

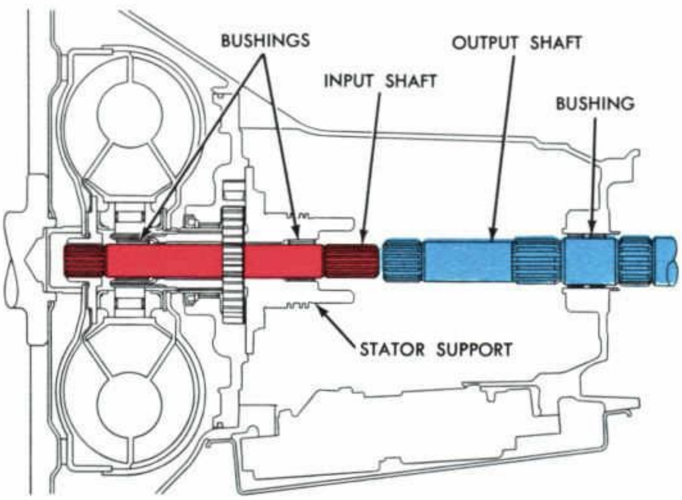


Fig. 12—Input and Output Shafts

FORWARD CLUTCH CYLINDER

The forward clutch cylinder (Fig. 13) is splined to the input shaft and centered inside the rear extension of the stator support. This cylinder will always turn at the same speed as the converter turbine, which is splined to the front end of the input shaft.

Notice, there are teeth cut on the inside of the cylinder to hold externally splined clutch plates. The teeth on the forward-facing hub of the cylinder are for internally splined clutch plates.

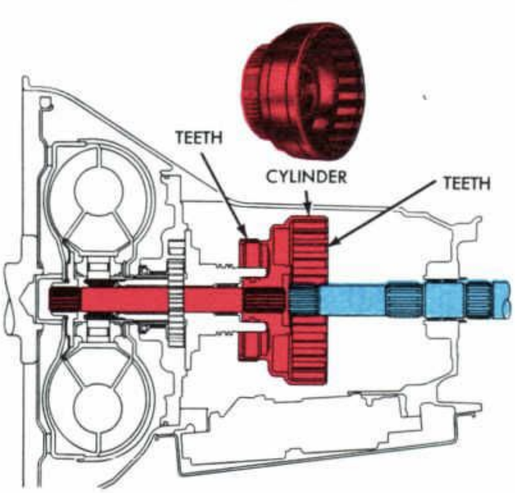


Fig. 13—Forward Clutch Cylinder

SUN GEAR

The C6 uses one sun gear (Fig. 14) which is common to two planetary gearsets. The sun gear is in-

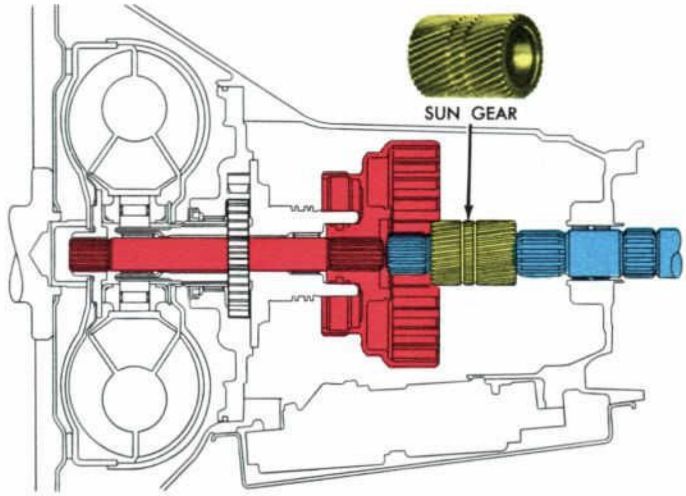


Fig. 14—Sun Gear

stalled on the output shaft and is freerunning there. Two bushings inside the sun gear turn against journals on the shaft.

FORWARD PLANETARY UNIT

The planet carrier of the forward planetary unit is splined to the transmission output shaft (Fig. 15). This gives us an output from the forward planetary unit to the rear wheels. The forward planetary unit, as we'll see later, is in operation in all forward gears.

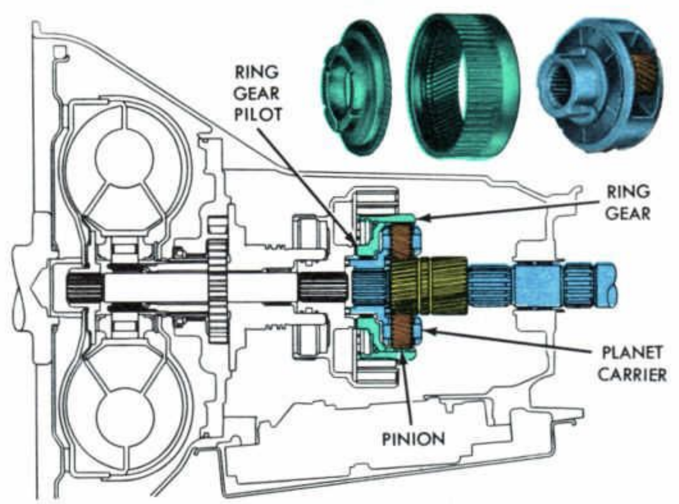


Fig. 15—Forward Planetary Unit

Ring Gear

The forward unit ring gear is piloted on the forward planet carrier hub. Teeth are cut on the outer diameter of the ring gear, which extends into the forward clutch cylinder. These teeth engage with the the clutch plates. Thus, the ring gear also is the forward clutch hub.

FORWARD CLUTCH

With alternating clutch plates splined to the inside of the front clutch cylinder and the outside of the forward ring gear and clutch hub (Fig. 16), we can now connect the transmission input shaft to the forward planetary unit ring gear.

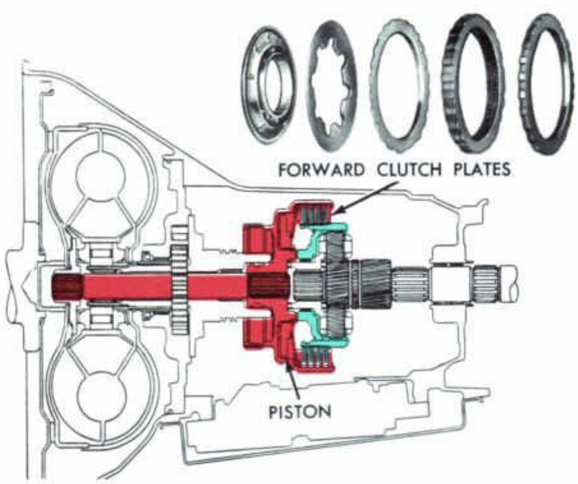


Fig. 16—Forward Clutch

When the driver moves the selector lever to any forward range, control pressure flows from the manual valve to the forward clutch piston. Pressure on the piston applies the clutch and locks the input shaft to the forward unit ring gear. Thus, the transmission input shaft drives the ring gear at converter turbine speed in all forward gears.

REVERSE-AND-HIGH CLUTCH

By adding the reverse-and-high clutch and the input shell (Fig. 17), we begin to see power flow possibilities. The high-and-reverse clutch cylinder is free-running on the stator support. Its clutch pack consists of alternating plates which are splined to the clutch cylinder and to the hub of the forward clutch cylinder. When this clutch applies, the reverse-and-high clutch drum is locked to the forward clutch cylinder.

The **input shell** is splined to the center of the sun gear and held in place by two snap rings. Lugs on the reverse-and-high clutch cylinder engage in slots

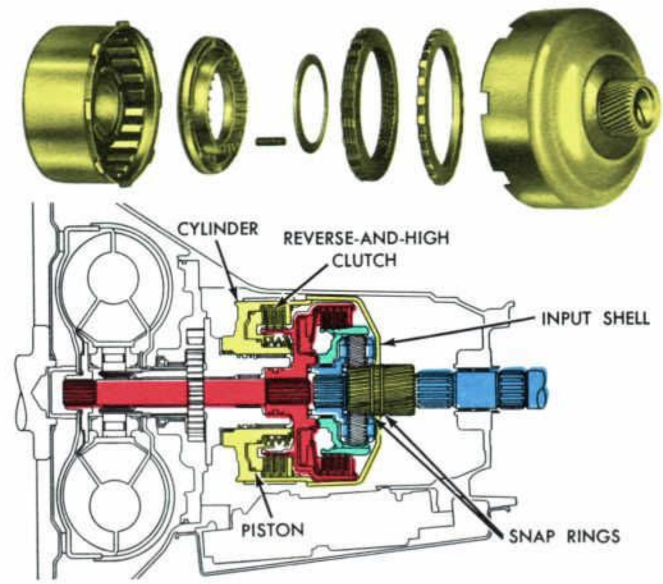


Fig. 17—Reverse-and-High Clutch

in the shell, so that the sun gear is mechanically connected to the reverse-and-high clutch drum.

Therefore, we now have two power flow possibilities. Engine power through the torque converter and to the input shaft and forward clutch cylinder can go two ways. With the forward clutch applied, power flows to the forward planetary unit ring gear. With the reverse-and-direct clutch applied, power flow is to the sun gear.

NEUTRAL

At this stage in our buildup, we have assembled all the parts involved in input to the gear train. If neither the reverse-and-high nor the forward clutch is applied, the input shaft cannot drive anything but the forward clutch cylinder. There is no input to the planetary gears and the transmission is in neutral.

HIGH GEAR

We are also far enough along in our buildup to get a direct drive through the transmission. In high gear (Fig. 18), both the reverse-and-high clutch and the forward clutch are applied. So the input shaft is locked to the sun gear **and** to the ring gear of the forward planetary unit. With these two members locked together, the whole planetary unit is locked up and turns with the input shaft. Since the planet carrier is splined to the output shaft, the output shaft is driven at input shaft speed.

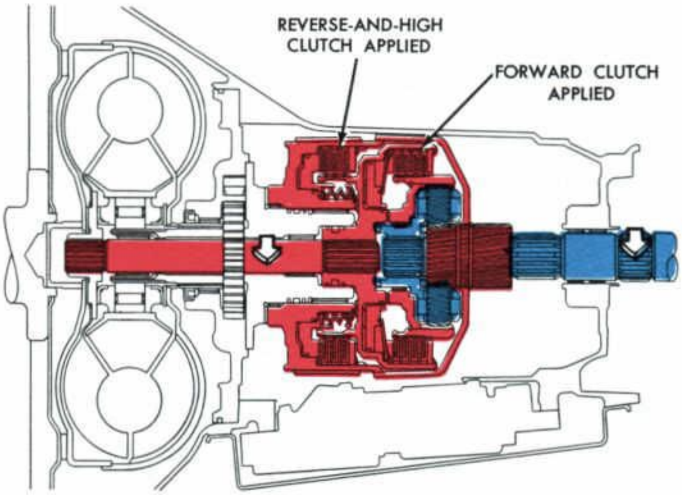


Fig. 18—High Gear

INTERMEDIATE BAND AND SERVO

Now, we can add the intermediate band and servo, and we will be able to get second gear from the forward planetary unit.

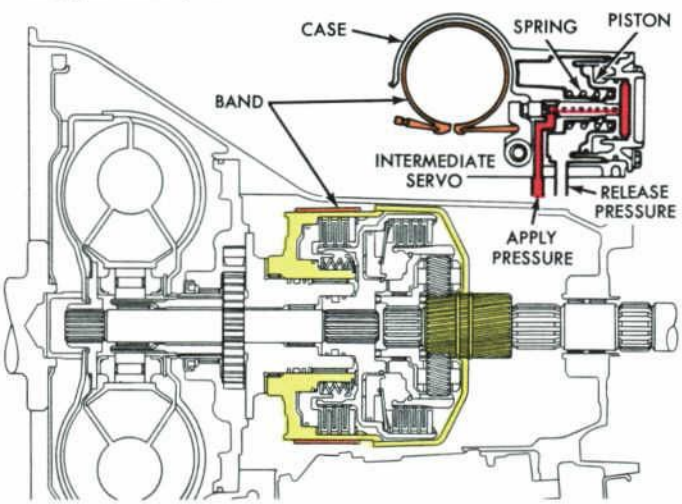


Fig. 19—Intermediate Band and Servo

The band (Fig. 19) is positioned around the outer drum surface of the reverse-and-high clutch. When **apply pressure** is directed to the **servo,** the servo piston moves to tighten the band around the drum and holds it stationary. Thus, the band holds the sun gear from turning when the servo is applied. The servo is housed in the main case.

The band is released either by relieving servo apply pressure or by directing **release pressure** to the opposite side of the piston. Release pressure and the piston spring together exert a high enough force on the piston to overcome apply pressure and release the band.

SECOND GEAR

In second gear (Fig. 20), the intermediate band is applied so that the sun gear is held stationary. The forward clutch also is applied so that the input shaft drives the forward planetary unit ring gear.

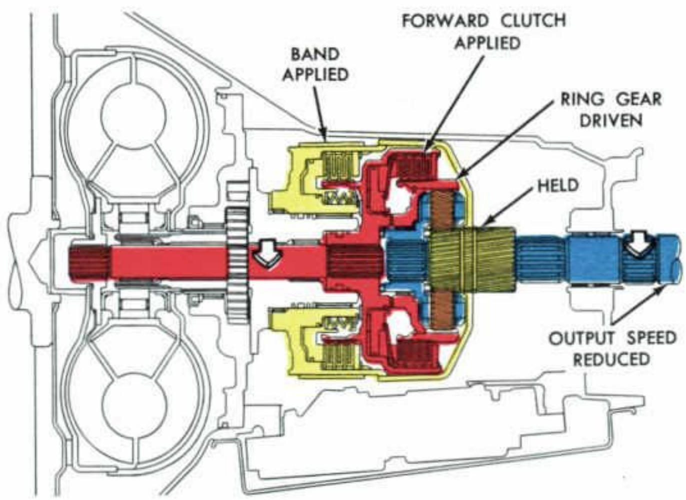


Fig. 20—Second Gear

As we've seen earlier, when the sun gear is held and the ring gear driven, (Fig. 10), the planetary pinions are forced to walk around the sun gear and carry the pinions or pinion carrier around at a slower speed than the input. The forward unit pinion carrier being splined to the output shaft, we now have the output shaft driven in the same direction as the input, but at a reduced speed.

LOW-AND-REVERSE PLANETARY UNIT

Before we can get any more gear combinations, we must complete our other planetary gearset. In the low-and-reverse planetary unit, we use the same sun gear as the forward unit. The sun gear is the **only** input to the low-and-reverse gearset. But we again have two power flow possibilities—from the reverse-and-high clutch through the input shell to the sun gear, or with the sun gear being driven as the output member of the forward gearset.

Ring Gear

The **low-and-reverse ring gear** (Fig. 21), is splined to a hub which in turn is splined to the output shaft. The output of the low-and-reverse unit will always be through the ring gear then. A snap ring at the front of the ring gear hub and another snap ring at the back of the parking gear (Fig. 1) control output shaft end play.

PLANETARY GEAR SYSTEM

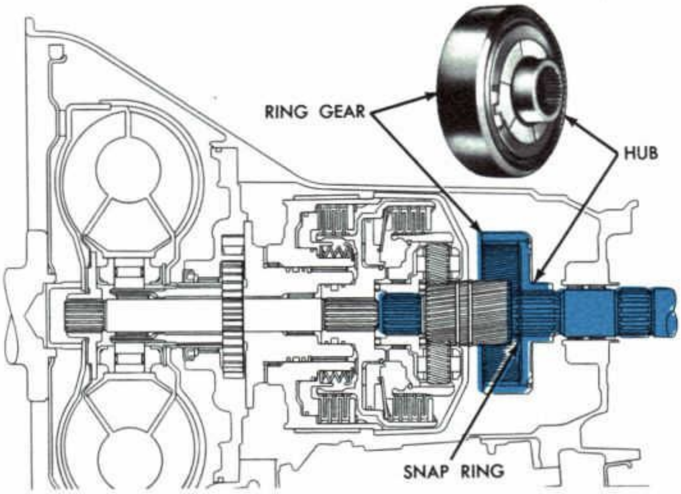


Fig. 21—Low-and-Reverse Ring Gear

Now, remember that to get reverse in a planetary gearset (Fig. 11), we hold the pinion carrier. The planet pinions act as idler gears and you drive one of the other members. We can drive the sun gear in this set and get an output through the ring gear then, by adding the low-and-reverse pinions and carrier, and a means of holding the carrier.

Pinion Carrier and Clutch

The **low-and-reverse pinion** carrier (Fig. 22) is splined to the **low-and-reverse clutch hub.** Internal-spline clutch plates on the hub alternate with external-spline plates in the low-and-reverse clutch cylinder. The cylinder is actually cast into the transmission case. When the clutch piston is actuated by control pressure, the clutch locks the pinion carrier to the case.

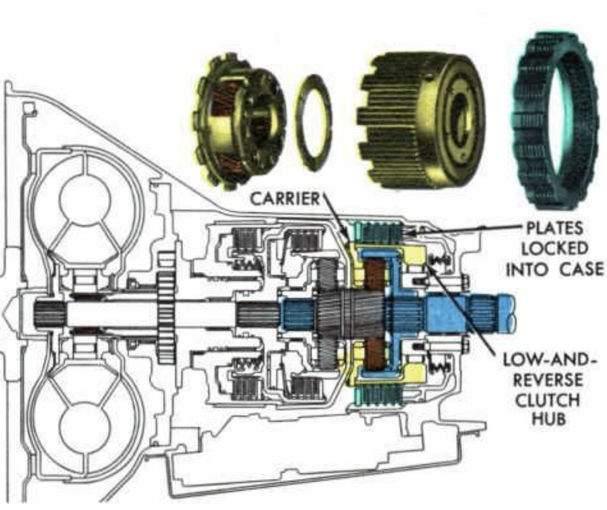


Fig. 22—Low-and-Reverse Pinion

REVERSE GEAR

For reverse gear, then, we apply the low-and-reverse clutch and hold the pinion carrier stationary (Fig. 23). We also apply the reverse-and-high clutch so that the input shaft drives the sun gear.

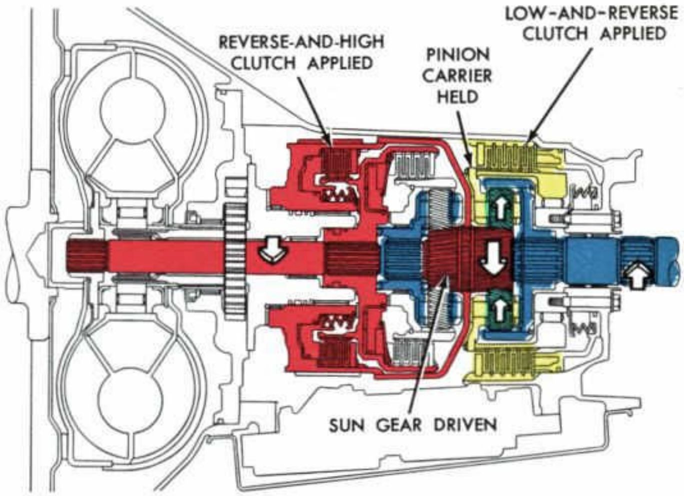


Fig. 23—Reverse Gear

With the carrier held and the sun gear driven clockwise, the pinions reverse the input rotation and drive the ring gear counterclockwise at a reduced speed. The ring gear turns the output shaft in reverse at a 2.175 to 1 reduction of input shaft speed.

Perhaps you are wondering what's going on in the forward planetary unit now. Of course, the pinion carrier is turning counterclockwise, because it is splined to the output shaft. Since the sun gear is turning clockwise, the pinions turn counterclockwise on their axes and drive the ring gear counterclockwise. But since the forward clutch is not applied, the ring gear just runs freely. In effect, the forward planetary unit is in neutral when the forward clutch is not applied.

Similarly, in second gear, the low-and-reverse unit is effectively in neutral with the pinion carrier turning freely.

MANUAL LOW GEAR

Low gear (Fig. 24) is a two-stage operation that we can best describe as a double reverse. The forward planetary gearset reverses input rotation and provides an output to the sun gear with a 1.13 to 1 reduction. The sun gear feeds this output to the low-and-reverse unit as an input. In the low-and-reverse unit, the rotation is reversed again and further reduced by the reverse gear reduction of

2.175 to 1. So the output shaft turns in the same direction as the input with a total reduction of 2.46 to 1.

Forward Planetary Unit

The forward clutch is applied in low gear (Fig. 24) and the input shaft drives the forward unit ring clockwise. Since the output shaft turns slower

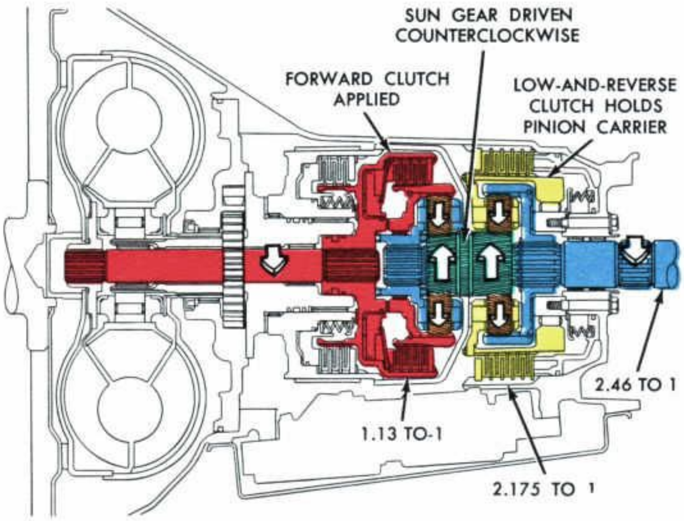


Fig. 24—Manual Low Gear

than the input, the planet carrier (which is splined to the output shaft) is in effect held. The pinions act as idlers then and drive the sun gear counterclockwise.

Low-and-Reverse Planetary Unit

In the low-and-reverse unit, the pinion carrier is held stationary by the low-and-reverse clutch. The sun gear, turning counterclockwise, drives the pinions clockwise and the pinions drive the ring gear clockwise. The ring gear hub turns the output shaft, then, in the same direction (clockwise) as the input shaft is rotating.

ONE-WAY CLUTCH

We have only to add a one-way clutch now to provide a freewheeling low gear in D1 range, and our gear train buildup will be complete.

The outer race of the one-way clutch (Fig. 25) is pinned to the low-and-reverse clutch hub and therefore, is connected mechanically to the low-and-reverse pinion carrier. The inner race is bolted to the transmission case. This clutch overruns anytime the pinion carrier turns clockwise, but it prevents the carrier from turning counterclockwise.

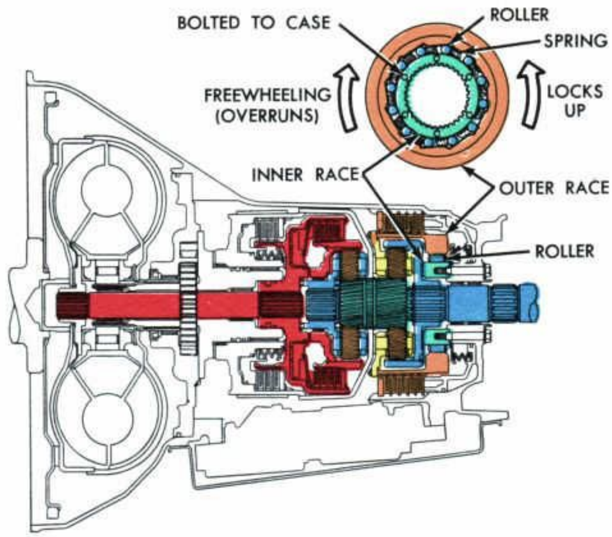


Fig. 25—One-Way Clutch

D1 LOW

In D1 range low gear (Fig. 25), only the forward clutch is hydraulically applied. The low-and-reverse pinion carrier is held from turning by the one-way clutch. Power flow is the same as in manual low The difference is that if the car starts downhill in D1 low , so that the rear wheels try to drive the engine, the one-way clutch unlocks and the car freewheels. In manual low, of course, the low-and-reverse clutch prevents the pinion carrier from turning either way, so the rear wheels can drive the engine. In other words, engine braking is possible in manual low but not in D1 low.

SUMMARY

For review, then, and for future reference, here is a capsule summary of the operation of the C6 planetary gear train:

Gear	Refer to Figures	Holding Members	Front Planetary Gearset			Rear Planetary Gearset		
			Driven	Held	Output	Driven	Held	Output
Manual Low	24	Forward Clutch Low-and-Reverse Clutch	Ring Gear	*Carrier	Sun Gear	Sun Gear	Carrier	Ring Gear
D1 Low	25	Forward Clutch One-way Clutch	Ring Gear	*Carrier	Sun Gear	Sun Gear	Carrier	Ring Gear
*The carrier is actually turning with the output shaft, but at a slower speed than the input.								
Second	20	Forward Clutch & Band	Ring Gear	Sun Gear	Carrier	EFFECTIVELY IN NEUTRAL		
High	18	Forward Clutch Reverse-and-High Clutch	Sun Gear Ring Gear	None	Carrier	TURNS AS A UNIT		
Reverse	23	Reverse-and-High Clutch Low-and-Reverse Clutch	EFFECTIVELY IN NEUTRAL			Sun Gear	Carrier	Ring Gear

HYDRAULIC CONTROL SYSTEM

Studying the C6 gear train buildup, you learned how the various gear combinations are obtained by applying a band and three multiple-disc clutches. We mentioned that these holding members were applied by fluid under pressure from the hydraulic control system. Now, it's time to see how the hydraulic system performs this and its other functions.

The hydraulic control system maintains a constant flow of fluid under pressure through the torque converter; it controls the upshifting and downshifting of the gear train to automatically furnish the torque needed to the rear wheels; it ensures that the shifts will be smooth under all driving conditions; and it lubricates and cools the internal parts of the transmission.

To do all this, the hydraulic system is necessarily complicated. That doesn't mean you can't learn how it works. And certainly you'll at least need a general knowledge of the operation of each of the hydraulic system components to be able to diagnose troubles effectively. But the word **each** is the real key to learning the system. We really have a number of smaller systems within the overall system, and we'll treat each of these smaller systems and each component individually.

In fact, after a quick review of hydraulics principles, we'll pretty much build up a hydraulic control system, much as we did the gear system. So you can learn the system in easy steps, before we discuss its overall operation in the various ranges and operating conditions.

HYDRAULICS PRINCIPLES

PASCAL'S LAW

It's pretty doubtful whether Blaise Pascal, the French scientist who discovered the fundamental principle of pressure hydraulics about 300 years ago, envisioned such an application of his Law as automatic control of a transmission. Pascal was no daVinci and had no interest in self-propelled machines. He was a theoretician, and his main interest in pressure hydraulics was as a means of applying leverage. But Pascal's Law is basic to any study of a pressure. Simply stated, Pascal's Law is this:

> Whenever force is applied to a confined fluid, pressure builds up; and the pressure is transmitted undiminished throughout the fluid, acting with equal force on equal areas of the surface of the container.

Pressure is the term we use to define how much force is exerted against a specific area. For ex-

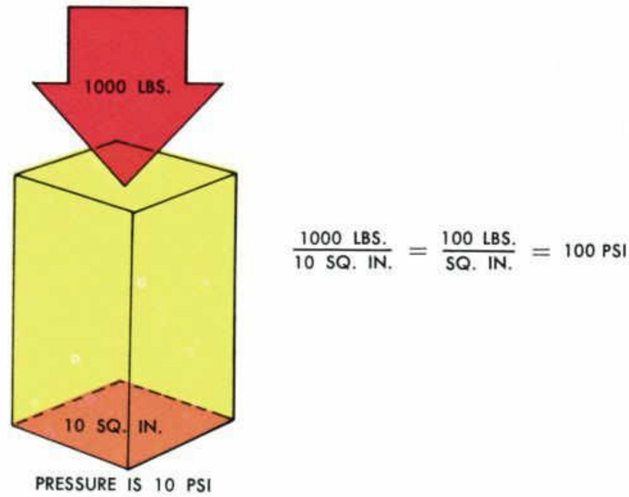


Fig. 26—Pressure is Force per Unit of Area

ample, if a force of 1000 pounds is exerted uniformly over a surface of 10 square inches (Fig. 26), the force on **each** square inch is 1,000 divided by 10 or 100 pounds. We say then that the pressure is 100 pounds-per-square inch or 100 psi.

FORCE EQUALS PRESSURE X AREA

Similarly, if a force of 1000 pounds is exerted against a hydraulic piston with a surface area of 10 square inches (Fig. 27), the fluid confined behind

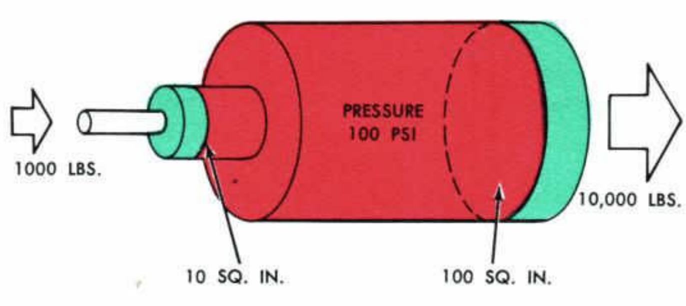


Fig. 27—Pressurizing Fluid

the piston will be under a pressure of 100 psi, and every square inch of the container will have 100 pounds of force exerted on it. If one surface of the container happens to be another piston with an area of 100 square inches, each subject to 100 pounds of force, the total force on the large piston equals the pressure multiplied by the piston area or 10,000 pounds.

FORCE = PRESSURE × AREA
FORCE = 100 psi × 100 square inches
FORCE = 10,000 pounds

Here then is the leverage or force multiplication or mechanical advantage Pascal was so intrigued by. And this is the fundamental concept that controls operation of our hydraulic control system.

Of course, we don't build pressure in the C6 hydraulic system by pushing on a piston. We have a rotary pump to force the fluid into the system and valves to regulate the pressure to the right amount needed to apply our clutches and band. Before we go into that, though, one or two more simple examples of the principle are in order.

CLUTCH APPLICATION

Suppose that we have a pressure of 100 psi exerted behind a clutch piston with an apply area of 20 square inches. The total force holding the clutch applied is one ton (Fig. 28).

FORCE = PRESSURE × AREA
FORCE = 100 psi × 20 square inches
FORCE = 2,000 pounds or 1 ton

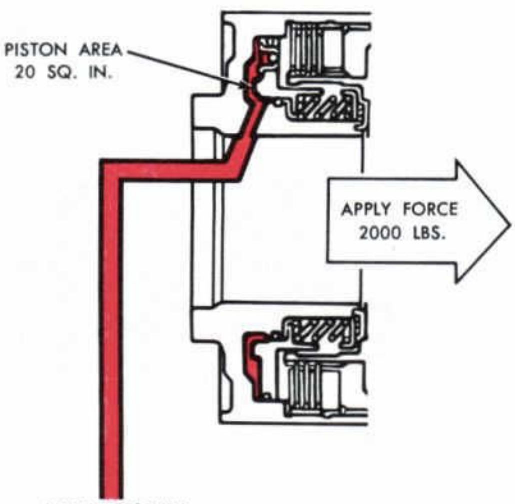


Fig. 28—Clutch Apply Force

The force needed to hold the clutch may be more or less than 2,000 pounds, depending on the torque being transmitted through the clutch. This is one reason we have the pressure regulated at different values, depending on the operating conditions.

DIFFERENTIAL AREAS

Figure 29 shows what happens when the same pressure works on different areas. The pressure on the large area resolves into a greater force than on the small area. With a 10-psi pressure acting on areas of five square inches and 10 square inches, we have total opposing forces of 50 pounds and 100 pounds. The pistons naturally move in the direction of the greater force.

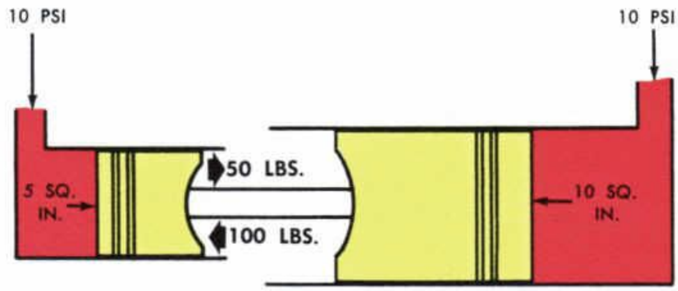


Fig. 29—Pressure on Different Areas

In the C6 hydraulic system, we'll see pressure on differential areas resulting in a force that causes movement of the controlling valves. A valve may have pressures working against several areas, or against plugs in contact with the valve (and a spring or two getting into the act also), resulting in several forces acting on the valve.

As we go through the system, we'll see how these forces act to control the valve positions and to regulate pressure.

THE PRESSURE SOURCE

Let's begin our study of the C6 hydraulic system by considering the source of pressurized fluid—the pump used to put the fluid into motion, the valves involved in regulating the pressure, and the basic supply circuits.

FLUID SUPPLY

The C6 transmission is supplied with enough fluid to keep the torque converter completely filled, to operate the hydraulic controls, and to lubricate the working parts. After these needs are met, there is still a reserve of fluid stored in the oil pan and bottom of the case—usually referred to as the **sump.** In the schematic diagrams in this section, the symbol X in a passage indicates that the passage leads to the sump.

The fluid used in all automatic transmissions is special. Automatic transmission fluid is composed of mineral oil and additives. In the transmission, it is used as a combination power-transmission medium, hydraulic control fluid, heat transfer medium, bearing surface lubricant, and gear lubricant. To meet the above requirements, the fluid must pass more than 25 special tests. In all cases, the manufacturer's recommendations should be followed when servicing the transmission fluid.

PUMP

The C6 has one pump, an internal gear pump (Fig. 30) which is driven by the flats on the converter impeller hub. The pump operates, then, whenever the engine is operating to supply fluid to the rest of the system.

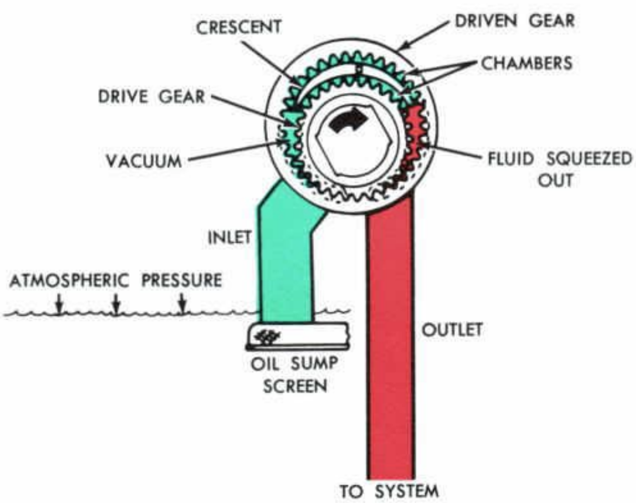


Fig. 30—Pump Operation

As the pump drive gear is driven by the impeller, it causes the internal driven gear to rotate also. Where the gears separate from mesh, a vacuum is created, and here is where we locate the pump inlet. Atmospheric pressure in the sump forces fluid into the inlet through the sump screen.

Fluid Chambers

At the point of greatest separation, the gears are closely fitted to a crescent in the pump housing. The crescent and the space between the gear teeth form chambers in which the fluid is trapped as the gears turn past the inlet. Beyond the crescent, the gears begin to come together again. Since the crescent seals the fluid from getting back to the inlet, it now must be squeezed out the outlet port and into the system.

Positive Displacement

A pump that has the outlet sealed from the inlet like this is called a **positive-displacement or positive-delivery pump.** This means that as long as the pump is turning and fluid is supplied to the inlet, the pump will deliver fluid—the volume being in proportion to the drive speed. The C6 pump is designed to deliver more fluid than the transmission needs, and excess pump delivery is recirculated to sump by the control pressure regulator valve.

CONTROL PRESSURE REGULATOR VALVE

The pump outlet is connected to what we refer to as the main control pressure system. In this system, only one valve, the control pressure regulator, can dump fluid back to sump. All the other valves lead to closed systems. After all the lines are filled, either the control valves or the clutches will offer a resistance to flow, depending on which range the transmission is in. Assuming we're in neutral, the main control pressure system is dead-ended at certain valves.

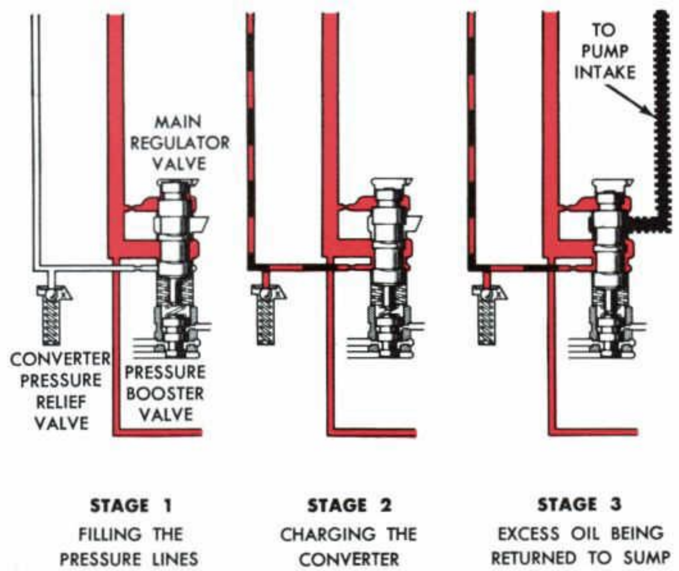


Fig. 31—Main Regulator Valve Operation

On the way to the control system, the fluid is subject to the control of the control pressure regulator valve. As shown in Fig. 31, the pump outlet is connected to two passages at the regulator valve. In the upper or controlling passage, the fluid flows between two lands with different diameters. When pressure builds up in this passage and works against the differential surface areas, it will result in a force tending to move the valve against spring force, or down as shown in the diagram. (Of course, the valves are all in horizontal positions in the valve body, but we'll use the terms "down", "up", etc. in this section to refer to positions on the schematic diagrams.) At the lower passage, the fluid is between two equal-sized lands, so there's no differential surface area and therefore, pressure forces (up and down) cancel.

Three Stages

We can consider the main regulator valve to have three stages of operation (Fig. 31). In the initial stage, while the lines are being filled, there is little resistance to flow in the system, so pressure doesn't build up. In this stage, the springs below the valve hold the regulator valve in the up or closed position.

(As you go through this section, it will be easy to understand that though all the lines are not always under pressure, they are kept full of fluid at all times. So when the valve is shifted, the transmission responds immediately. Because of this, the system usually needs only enough fluid from the pump to make up for internal leakage. So the first stage of regulation occurs immediately when the pump begins to rotate.)

Converter Supply

As pressure begins to rise (about 60 psi), the regulator valve is forced down against the springs, and another port is uncovered (Fig. 31b). Now, fluid from the pump can flow into the converter circuit, and the converter will become pressurized.

The converter also is kept filled all the time, so this second stage, too, happens immediately. When the converter is pressurized, we again need a path for the pump delivery if we want to prevent pressure from building excessively.

Sump Passage

So now we come to the third stage of regulation, which is the usual condition when the engine is operating. The regulator valve is forced down farther against the springs (Fig. 31c) and opens a passage to sump. All pump delivery not needed by the system or converter is now returned to the pump inlet.

Balanced Valve

The pressure in the main control pressure system now is being regulated by balancing the pressure against the force of the valve springs. In other words, the springs control the pressure, and the valve adjusts itself automatically so that the spring force acting upward is equal to the hydraulic pressure force acting downward. If the pressure tries to drop, the springs will move the valve up and cut off part of the flow to sump, and even to the converter circuit if necessary to maintain the regulated pressure. If the pressure tries to rise, the valve moves down. We call the main regulator valve a **balanced valve,** and we call the pressure it regulates **control pressure.**

CONVERTER AND COOLER SYSTEM

Before following the control pressure line into the main control pressure system, let's go back to that first port the regulator valve opened and take a closer look at the converter and cooler hydraulic system.

CONVERTER-IN FLOW

From the main regulator valve, fluid flows through the valve body and case (Fig. 32) to the pump hous-

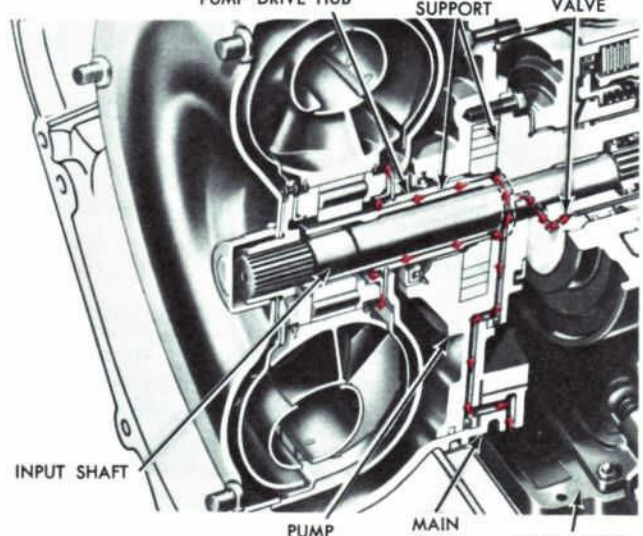


Fig. 32—Converter-In Flow

ing, to the stator support and into the converter housing through a closed passage between the stator support and the impeller hub. In this part of the converter circuit, we find two valves—the converter pressure relief valve and the drain-back valve.

Converter Pressure Relief Valve

The converter pressure relief valve (Fig. 33) limits the maximum pressure that can build up in the converter circuit to about 90 psi, no matter how high control pressure goes. (As we'll see later, control pressure can go above 200 psi in certain conditions.) A pressure higher than about 90 psi will open the relief valve and exhaust some fluid back to sump. Of course, when the pressure drops below 90 psi, the spring closes the valve.

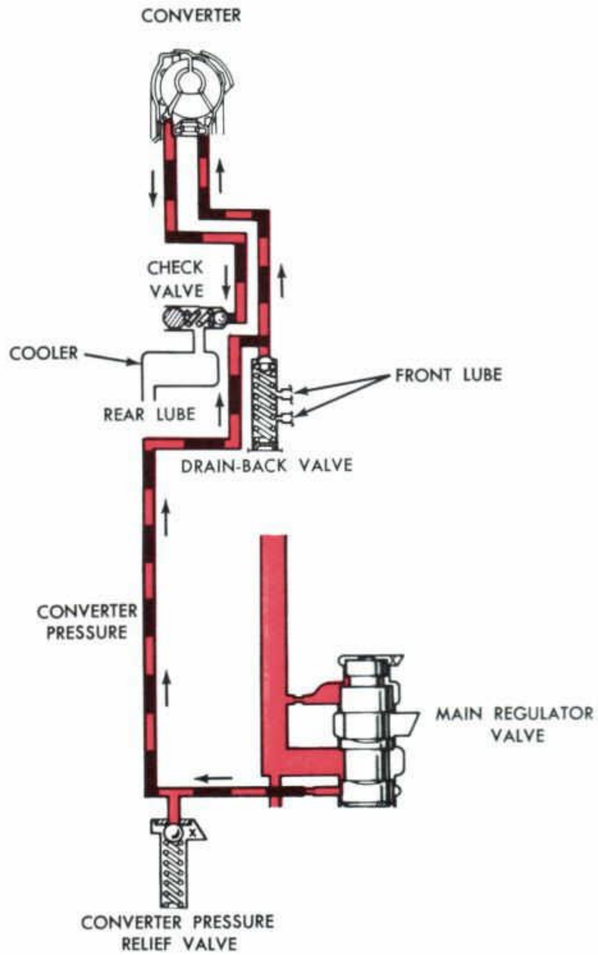


Fig. 33—Converter and Cooler System

Front Lube

The converter-in circuit also provides fluid to lubricate the front part of the planetary gear train. The **drain-back valve** opens at about five psi to let the fluid into the front lubrication passages. Orifices in the passages prevent excess flow and high lubricating pressure.

Drain-Back Valve

The purpose of the drain-back valve is simply to prevent the converter fluid from draining through the front lubrication system when the engine is stopped.

CONVERTER-OUT FLOW

Fluid flows behind the front stator support bushing (Fig. 34) and between the stator support and input shaft into the stator support flange. From there, it flows past the converter check valve, into the pump housing and case, and to the cooler in the radiator through tubing. Returning from the cooler, the fluid flows to the rear lubrication system (Fig. 35) and to sump.

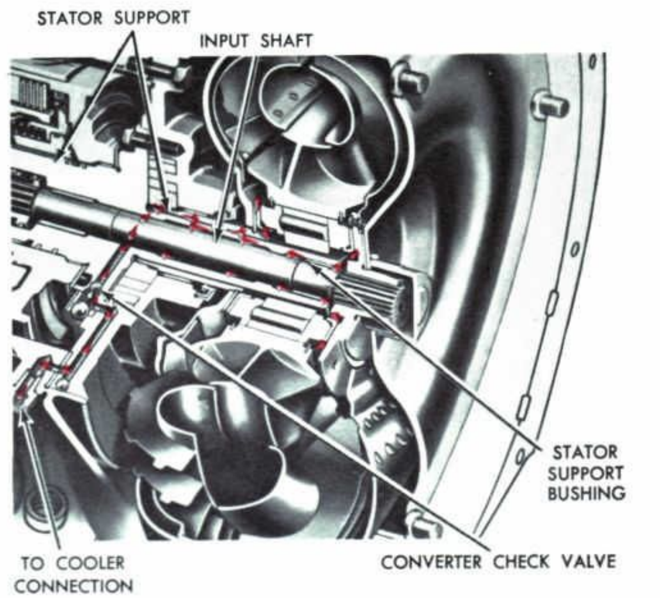


Fig. 34—Converter-Out Flow

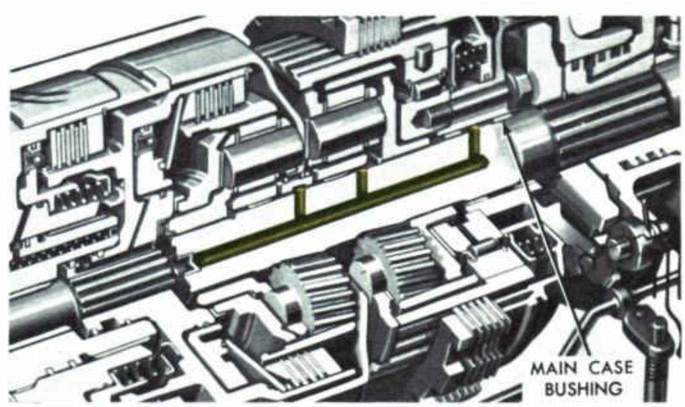


Fig. 35—Rear Lubrication System

Converter Check Valve

The converter check valve has two functions. It maintains at least 10 psi in the converter when the engine is operating and prevents the converter from draining through the cooler when the engine stops.

CONTROLLING THE GEAR TRAIN

Until now, we have avoided mentioning any particular valves until we're ready to discuss them. But now as we go on to see how the valve system controls the gear train operation, we find that many valves are so closely interrelated that some valves must be mentioned before it's time to see how they operate. Don't let this bother you. Concentrate on the valve being discussed. The others will come up later, and they'll all be tied together before we're finished.

MAIN CONTROL PRESSURE SYSTEM

Following the control pressure line from the regulator valve (Fig. 36), we find that control pressure is directed to two ports at the manual valve, to the primary throttle valve, to the throttle booster valve, and under the 1-2 accumulator valve. This is the basic main control pressure system. Control pressure is present in all the passages shown anytime the main regulator valve is operating in a balanced condition; that is, whenever pressure is being regulated.

MANUAL VALVE

The manual valve is an on-off valve. Its function is to direct control pressure to certain systems to apply the holding members which are involved in starting out in each range, and also to furnish control pressure to the valves involved in automatic shifting in each range.

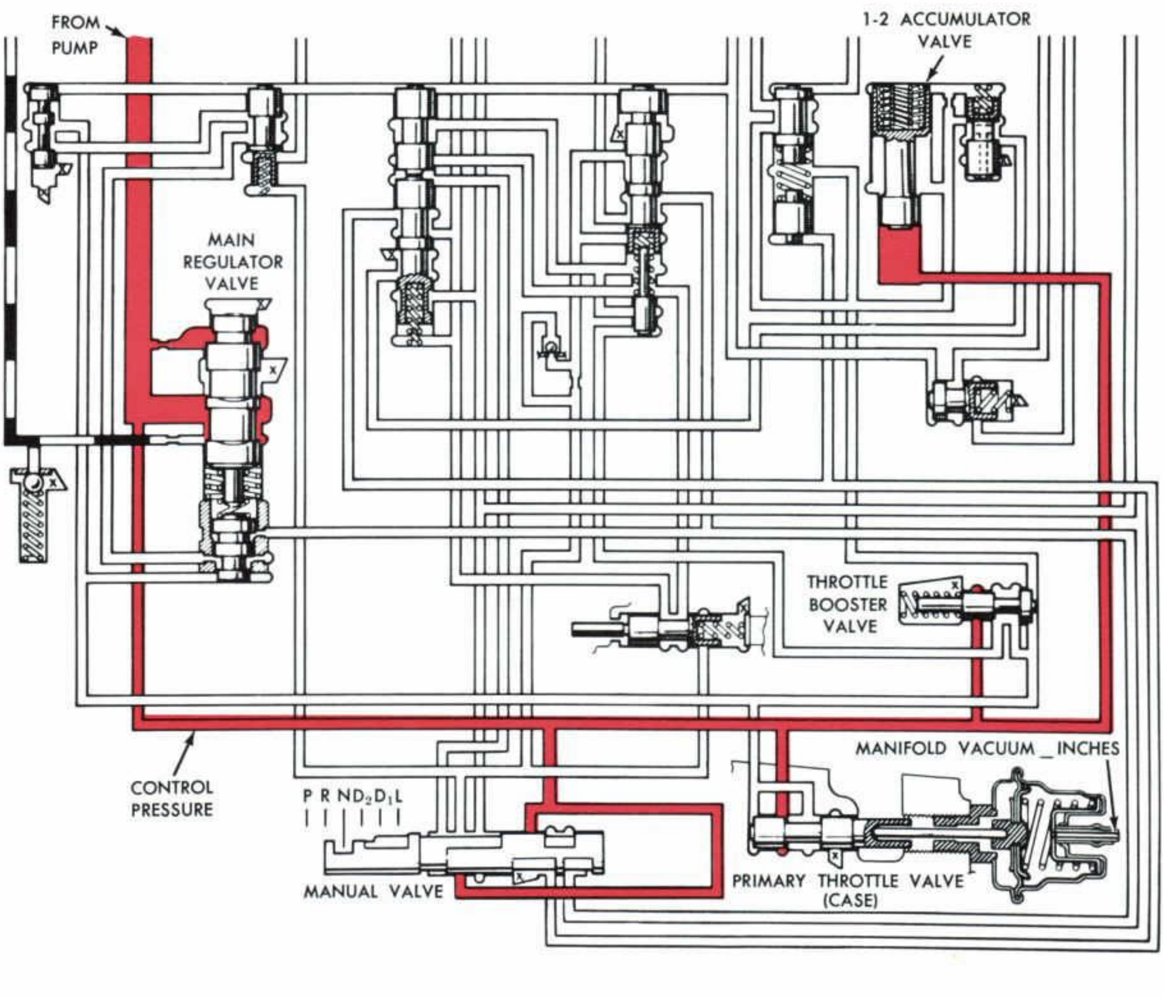


Fig. 36—Main Control Pressure System

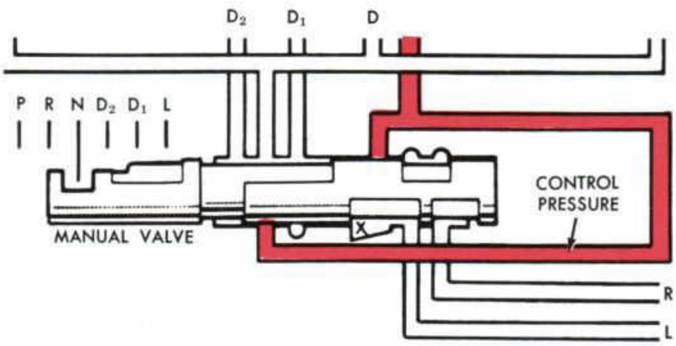


Fig. 37—Manual Valve Passages

A mechanical linkage from the shift selector controls the manual valve position. The valve is detented in each position for positive positioning.

There are five passages for control pressure routing from the manual valve (Fig. 37), each passage leading to separate systems. From left to right, these passages and the systems they charge with control pressure are:

Passage	Figure Reference	Charged In	System(s)
D2	39	D2 Only	First Gear Lockout System
D1	45	D2 & D1	Shift Control Supply System
D	38	D2, D1, L	Forward Clutch & Governor System
L-R	40, 61	L & R	Low-and-Reverse Apply System & Second-and-High Gear Lockout System
R	41	R Only	Reverse Pressure Booster System & Reverse-and-High Clutch Apply System

The figure number references are included because all these systems are not of interest to us right now, and some are illustrated farther on.

Forward Clutch and Governor System

Since we start in a different gear in each range, we are immediately concerned with the manual valve function of routing control pressure to the appropriate holding members. The forward clutch must be applied in all forward gears, so let's look at its system first.

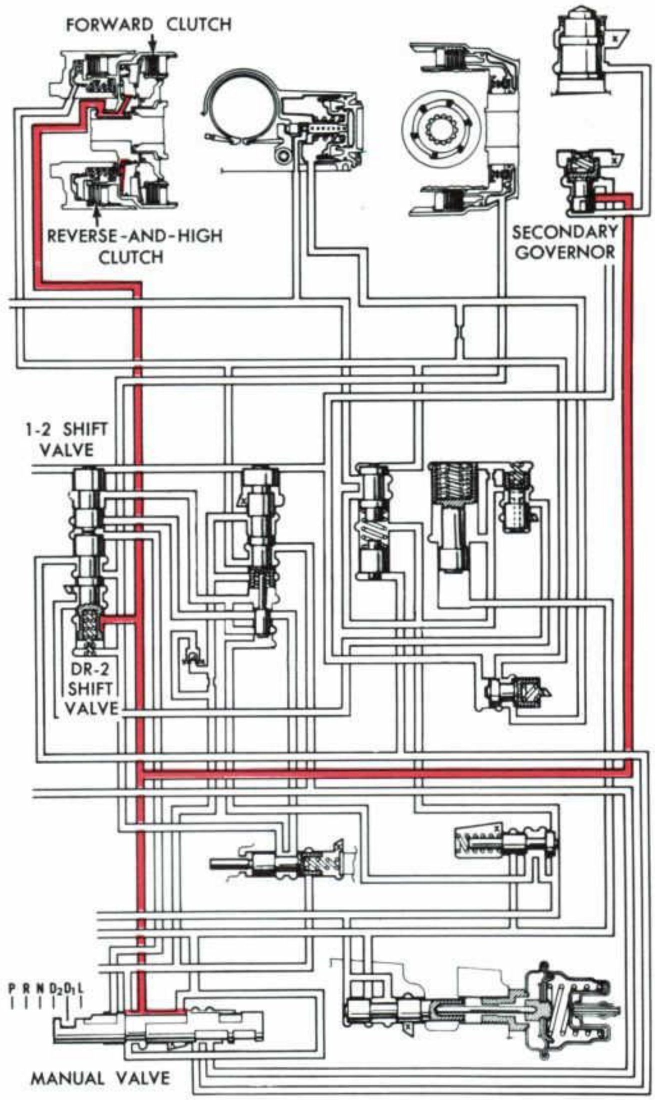


Fig. 38—Forward Clutch and Governor System

In D2, D1 and L ranges, the manual valve directs control pressure to the "D" passage (Fig. 38) to charge the forward clutch and governor. Besides being routed to the clutch and governor, control pressure is connected to a passage at the DR2 valve, where it will be used to charge the servo apply system when the DR2 valve shifts.

First Gear Lockout System

The first gear lockout system prevents the transmission from downshifting to low gear in D2 range. Control pressure is ported between the 1-2 shift valve and the DR2 valve (Fig. 39), and the DR2 valve is forced down. Let's say for now that anytime the DR2 valve is down, a shift to low gear is impossible, and we'll explain why later.

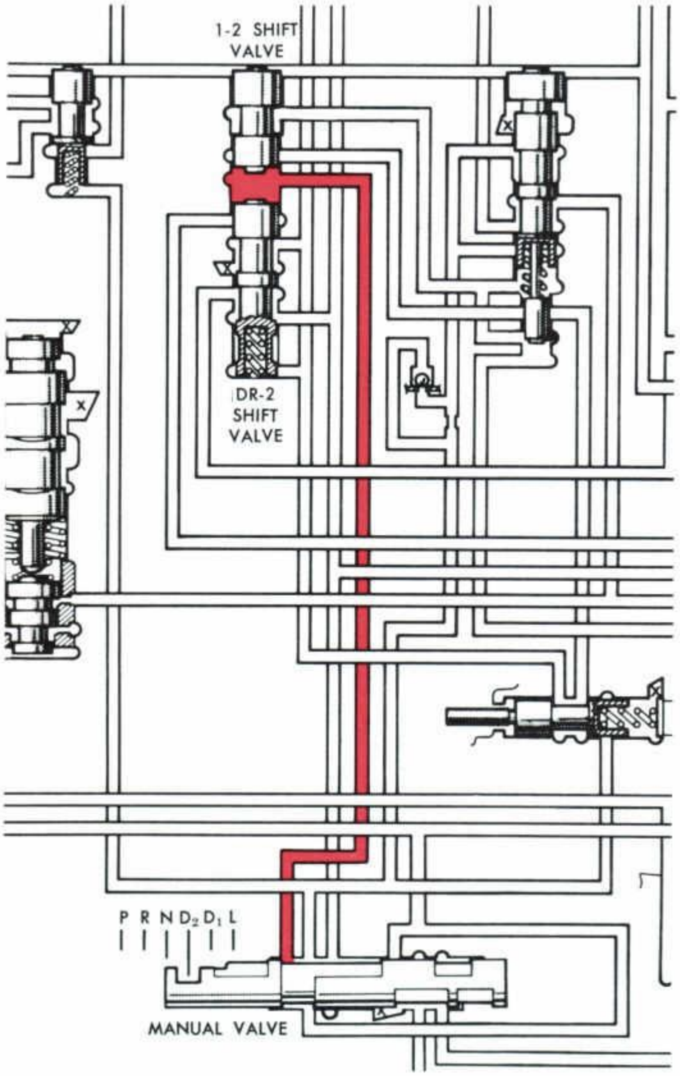


Fig. 39—First Gear Lockout System

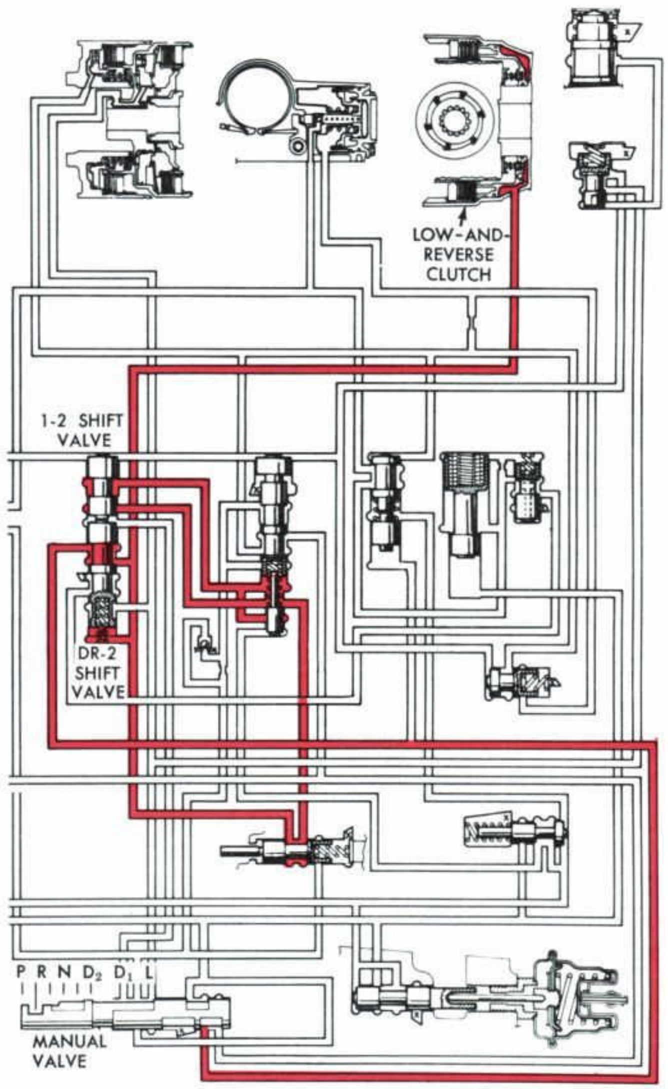


Fig. 40—Low-and-Reverse Clutch Apply System

Low-and-Reverse Clutch Apply System

The low-and-reverse clutch apply system (Fig. 40) is charged through the "L-R" passage in the low-and-reverse ranges. Pressure is transmitted to the clutch piston through the 1-2 shift valve.

Reverse-and-High Clutch Apply System

In reverse range, the manual valve "R" passage charges two systems (Fig. 41)—the reverse-and-high clutch apply system and the reverse pressure booster system.

The reverse-and-high clutch apply system directs pressure to apply the clutch and to release the servo. This system also can be charged from the "D1" passage when the 2-3 shift valve is upshifted for high gear, as we'll see later.

Reverse Pressure Booster System

The reverse pressure booster system sends full control pressure to differential areas of the pressure booster valve in reverse only. The pressure booster valve is forced up and increases the spring force acting on the regulator valve.

It takes a higher pressure to balance the valve, then, so control pressure rises. We need higher control pressure in reverse because of the high-torque operation.

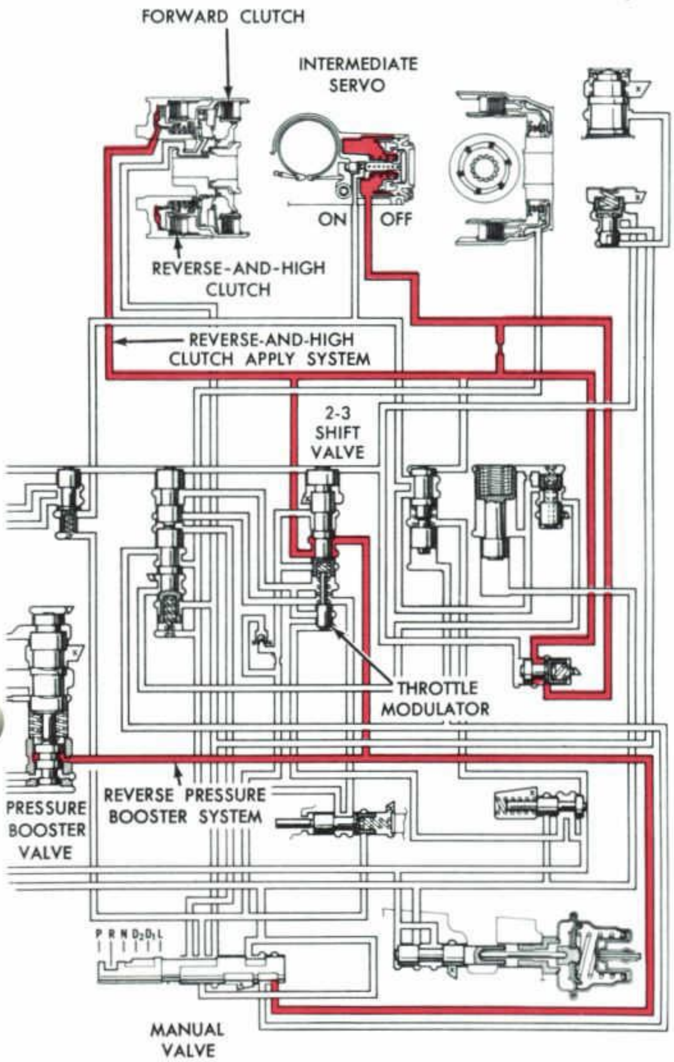


Fig. 41—Reverse-and-High Clutch Apply System and Reverse Pressure Booster System

D1 Start

Starting in D1 range, we are in low gear, and the forward clutch and the one-way clutch are the holding members. Therefore, all we need to do to start in D1 is charge the forward clutch and governor system (Fig. 38). The D1 passage also is charged so we can get automatic upshifts and downshifts. We'll look at that later.

D2 Start

Starting in D2, the forward clutch is applied through the "D" passage and the DR2 valve is forced down by the first gear lockout system.

Intermediate Servo System

When the DR2 valve is down, the intermediate servo system (Fig. 42) is charged by the forward clutch and governor system. Pressure is transmitted between the lands of the DR2 valve to and through the 1-2 scheduling valve, 1-2 accumulator valve and 2-3 back-out valve to the apply side of the servo. The servo piston moves to apply the band. With the forward clutch also applied, the transmission is in second gear.

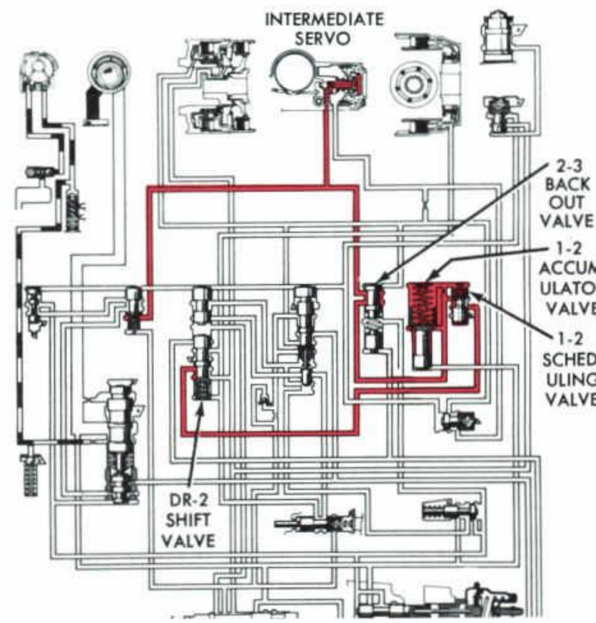


Fig. 42—Intermediate Servo Apply System

Manual Low Start

A manual low start is a combination of the systems illustrated in Fig. 38 and Fig. 40. The forward clutch and the low-and-reverse clutch are applied.

Reverse

In reverse, the low-and-reverse clutch and the reverse-and-high clutch are applied. The systems illustrated in Figs. 40 and 41 are charged.

SHIFTING THE GEARS

Now that we've seen how the manual valve gets control pressure to the holding members to start out in each range, we can go on to study the upshifts and downshifts in D1 and D2, and the valves that control them. We'll start with the shift valves.

SHIFT VALVES

Shift valves are on-off valves used to change the routing of control pressure to shift to a higher or lower ratio. In the C6, we have a 1-2 shift valve train to control the 1-2 and 2-1 shifts and a 2-3 shift valve to control the 2-3 and 3-2 shifts (Fig. 43). The shift valves have two positions, and are controlled by pressure signals from the governor, throttle valve and downshift valve. When there is no pressure acting on them, the valves are held in the up or downshifted positions by springs.

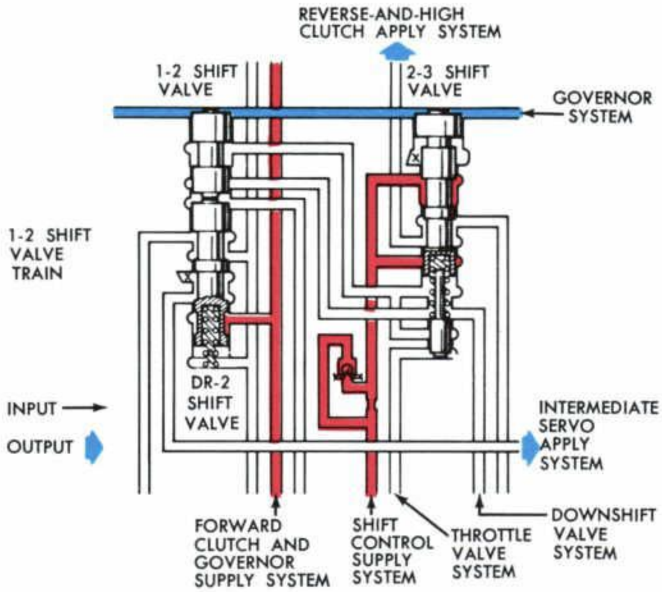


Fig. 43—Shift Valves

Remember now that the forward clutch stays on in all forward gears. To upshift to second gear, the 1-2 shift valve train must apply the servo, which will take over from the one-way clutch. To upshift to high, the 2-3 shift valve must release the servo and apply the reverse-and-high clutch (see table on page 12).

1-2 UPSHIFT

All we need to do to make the 1-2 upshift is get control pressure to the apply side of the servo; that is, charge the servo apply system. We have already seen how control pressure to charge the servo apply system is supplied from the "D" (forward clutch and governor) passage. When the 1-2 valve train is up (downshifted) (Fig. 43), this pressure is blocked and the servo apply system is relieved to sump. When governor pressure on the 1-2 valve forces the valve train down (Fig. 44), the DR2 valve blocks the sump passage and routes pressure from the "D" passage to apply the servo. Shifting the valve train back up reverses the process. The servo piston spring releases the band so that the one-way clutch must take hold again and the transmission returns to first gear.

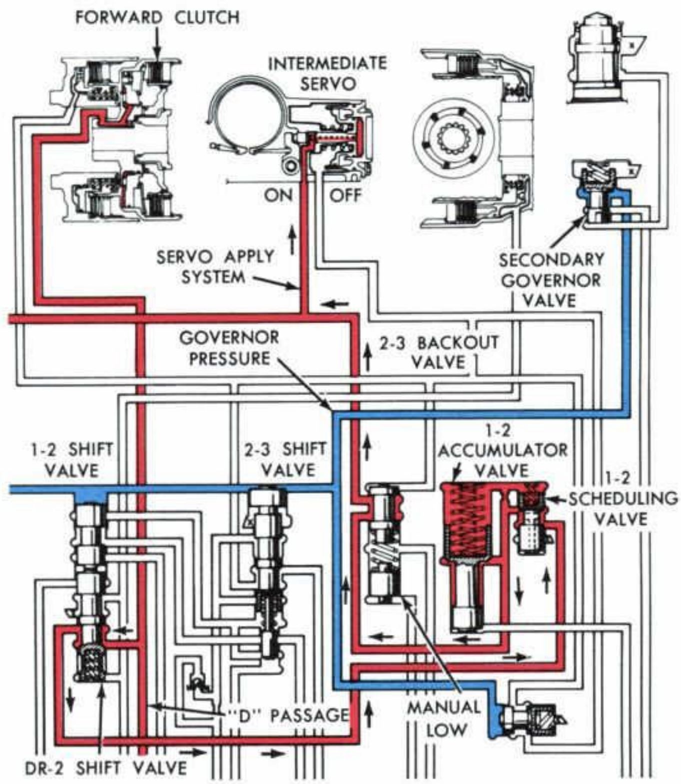


Fig. 44—1-2 Upshift

SHIFT CONTROL SUPPLY SYSTEM

Control pressure for the 2-3 upshift is supplied by the shift control supply system from the manual valve "D1" passage (Fig. 45). This system also supplies control pressure under the coasting boost valve and to the downshift valve in D1 and D2 ranges.

2-3 UPSHIFT

When governor pressure moves the 2-3 shift valve down (Fig. 46), control pressure charges the reverse-and-high clutch apply system. At the same time the clutch applies, we have direct control pressure to the release (off) side of the servo piston. The surface area is larger on the release side than on the apply side, so the unbalanced force resulting releases the band.

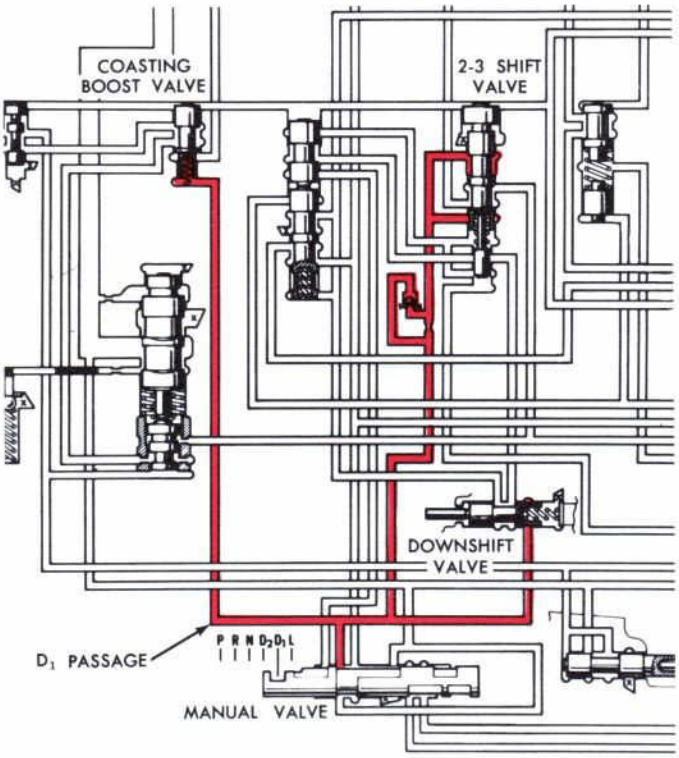


Fig. 45—Shift Control Supply System

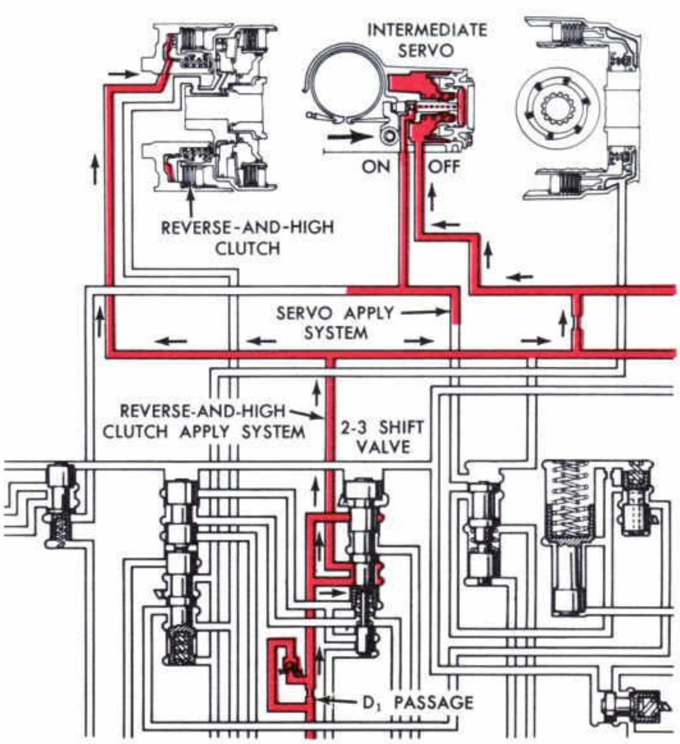


Fig. 46—2-3 Upshift

When the 2-3 shift valve moves back up (Fig. 47) the control pressure is blocked and the clutch apply system is relieved to sump. Springs release the clutch piston, and apply pressure in the servo puts the band back on, so the transmission downshifts to second.

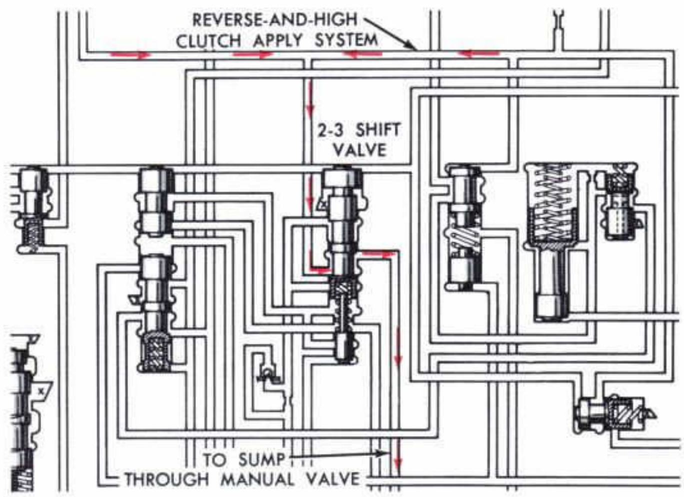


Fig. 47—3-2 Downshift

GOVERNOR OPERATION

Having seen the basic operation of the shift valves, we now can look at the sources of the pressure signals that control their position, and what these pressure signals do. We'll see that the governor and throttle valve not only control the shift valve positions, but also have an effect on the regulated control pressure.

ROAD SPEED SIGNAL

The governor is the road speed signal to the hydraulic control system. It puts out a pressure signal that is proportional to the road speed at any forward speed above 10 mph.

In the C6 transmission, the governor (Fig. 48)

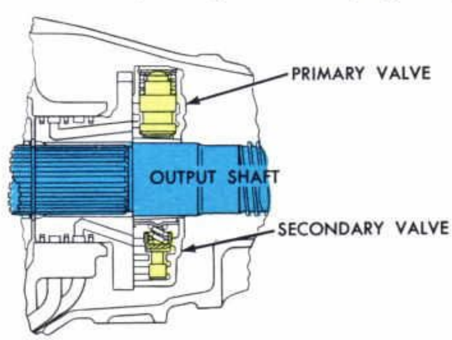


Fig. 48—Governor

consists of two valves in a housing that is splined to the output shaft. The primary governor valve prevents governor pressure from building up under 10 mph. The secondary governor valve functions as a balanced valve to furnish a pressure in proportion to output shaft speed.

VALVE SPRINGS

When the transmission is in neutral and the car is stopped, there is no pressure of any kind at the governor (Fig. 49). The primary valve is held in by its spring and the secondary valve is held out by its spring.

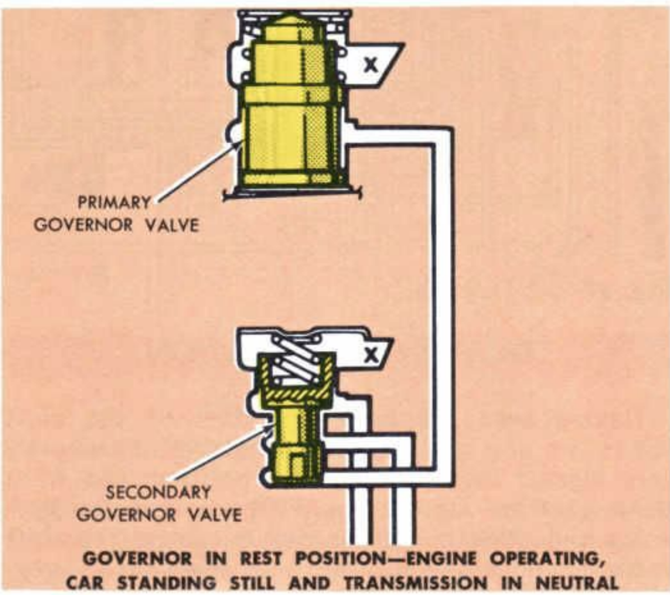


Fig. 49—Governor Operation—Car Stopped

Suppose now that the driver shifts to any forward gear, but the car is still stopped. Control pressure from the "D" passage (forward clutch) is now routed to the governor (Fig. 50). This pressure first acts on the face of the secondary valve's large land and pushes the valve in. Moving the secondary valve in opens a connecting passage to the primary valve and control pressure is directed to a dead-end between the primary valve lands. Now we have full control pressure against the outer end of the secondary valve holding the valve in against its spring.

GOVERNOR PRESSURE

When the car speed gets to about 10 mph, centrifugal force is enough to overcome the primary valve spring. The valve moves out and relieves the connecting passage to sump. With this pressure relieved, the secondary valve can move out and crack

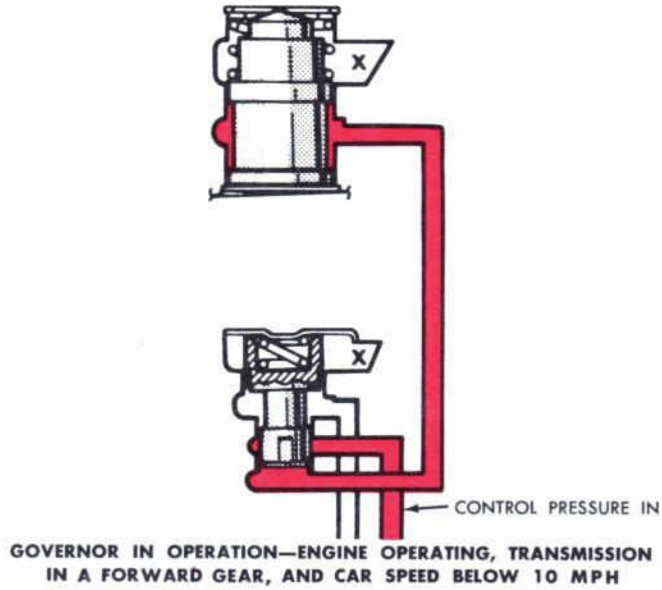


Fig. 50—Governor Operation—Below 10 mph

the control pressure line to the governor pressure port. Now the secondary governor valve becomes a balanced valve—governor pressure acting **in** is balanced against the sum of spring force and centrifugal force acting **out.** Increasing the car speed now will increase governor pressure (Fig. 51).

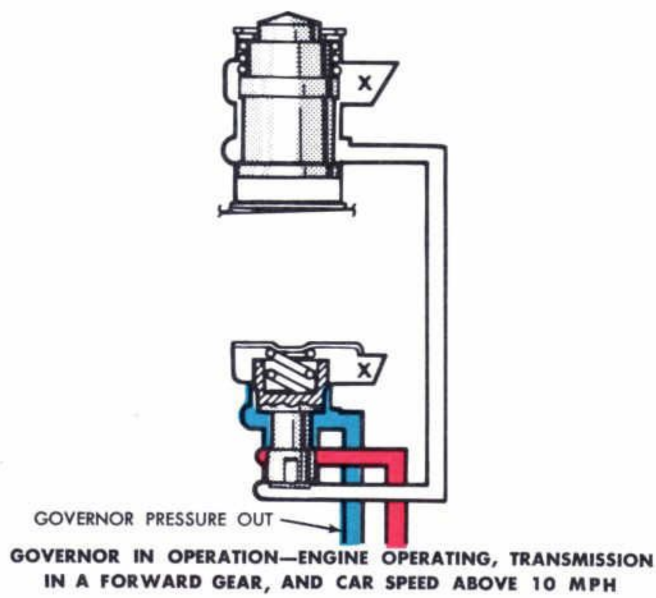


Fig. 51—Governor Operation—Above 10 mph

UPSHIFT

Governor pressure is first directed to the ends of the shift valves (Fig. 52). A force is exerted on the

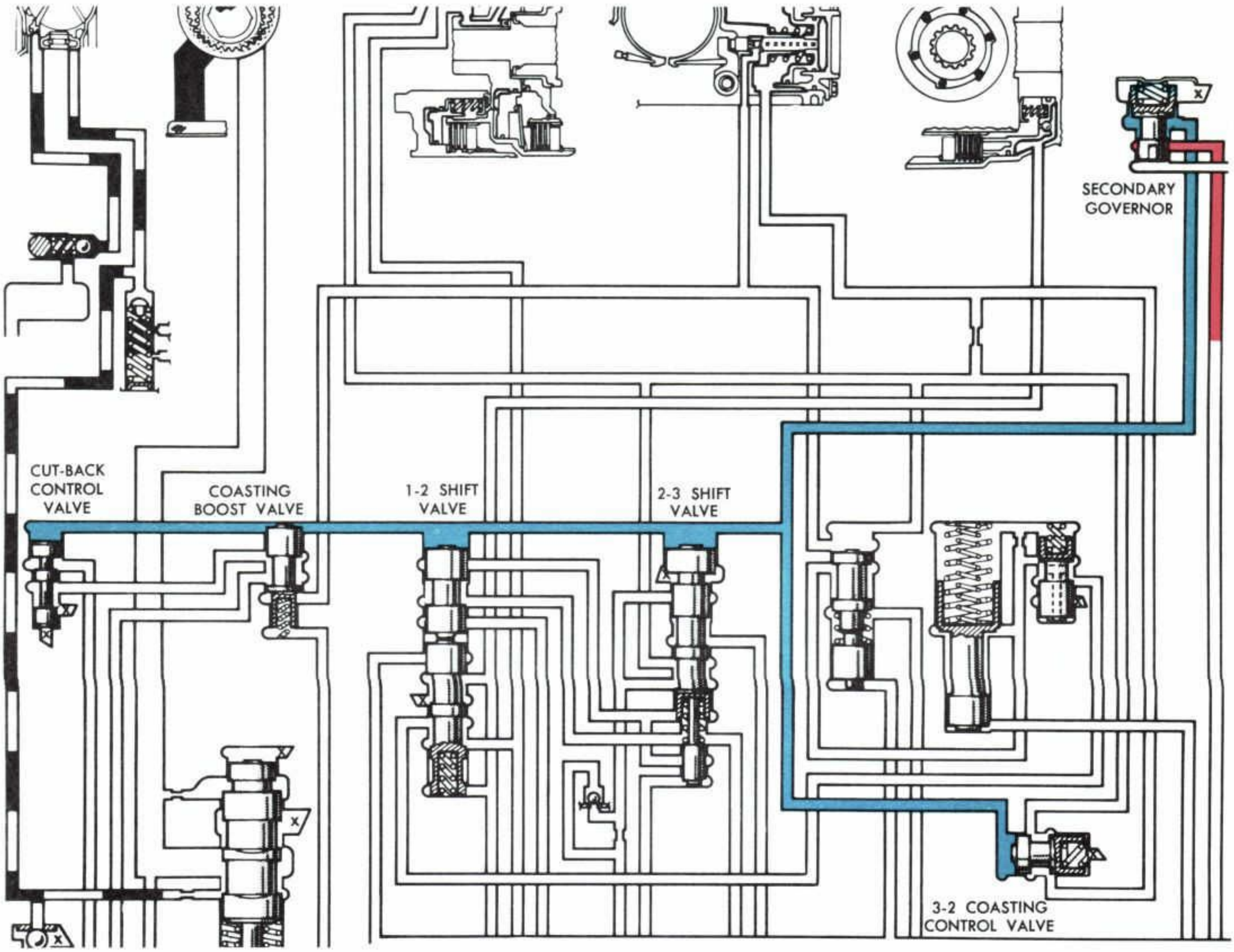


Fig. 52—Governor System

shift valves to move them to the upshifted (down) positions, when the force is great enough to overcome the forces holding the valves up.

When the road speed drops to 10 mph in high gear, governor pressure is cut off and both shift valves move up together, causing a 3-1 downshift.

Beyond the shift valves, governor pressure is also effective against the ends of the cut-back control valve, the coasting boost valve and the 3-2 coasting control valve. We'll see how these valves work later on.

THE THROTTLE PRESSURE SYSTEM

Throttle pressure is the engine load or torque demand signal to the hydraulic control system. In simplest terms, throttle pressure tells the shift valves to delay the upshifts and tells the main regulator valve to increase control pressure when the driver is calling for high torque to accelerate the car.

THROTTLE VALVE

Throttle pressure is produced in the throttle valve which is located in the case at the lower right rear. The pressure output from the throttle valve is inversely proportional to the engine vacuum, which is sensed by a spring-loaded vacuum diaphragm (Fig. 53).

Without the diaphragm, we would have a simple balanced valve with throttle pressure balancing spring force. When control pressure to the valve is

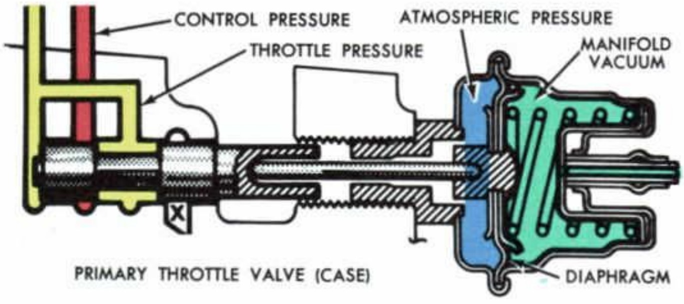


Fig. 53—Throttle Valve Operation

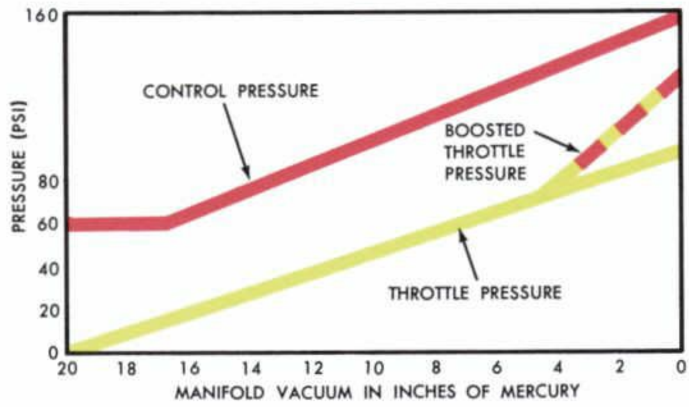


Fig. 55—Pressure Rise with Throttle Opening

cracked to the throttle pressure port, we immediately get a pressure against the end of the valve opposite the spring. If this pressure tries to rise too high, it pushes the valve to the right and closes the control pressure passage so that throttle pressure drops. If the throttle pressure tends to drop, the spring pushes the valve to the left to open the control pressure passage and increase control pressure. Thus, throttle pressure depends entirely on the force of the spring.

Vacuum Reduces Spring Force

Manifold vacuum is effective against the spring side of the diaphragm and atmospheric pressure is effective against the opposite side. In effect, vacuum reduces the force of the spring on the valve and so reduces throttle pressure.

For example, 20 inches of vacuum is the equivalent of about 10 psi absolute, while atmospheric pressure is about 15 psi absolute (Fig. 54). So we

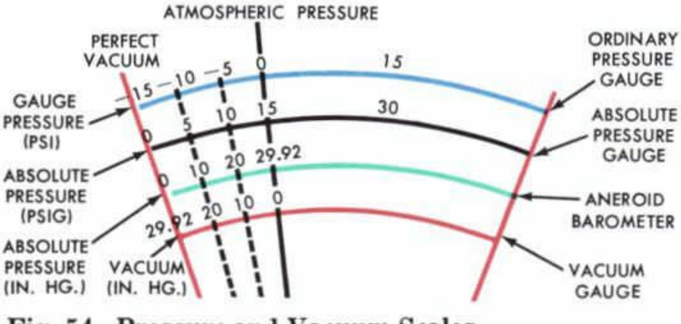


Fig. 54—Pressure and Vacuum Scales

have a resultant pressure of 5 psi opposing the spring and reducing pressure. As a matter of fact, throttle pressure is zero at 20 inches or more of vacuum.

As the engine is put under a load, vacuum drops and more of the atmospheric pressure is offset. Then we have a higher effective diaphragm force to the left, requiring more throttle pressure to balance the diaphragm force against the throttle valve force. Throttle pressure increases steadily from 0 psi at 20 inches of vacuum to about 80 psi at zero vacuum (Fig. 55).

ALTITUDE-COMPENSATED DIAPHRAGM UNIT

Some C6 transmissions are equipped with an altitude-compensating diaphragm unit. This unit (Fig. 56) incorporates an evacuated bellows that is sensitive to barometric pressure. Barometric pressure

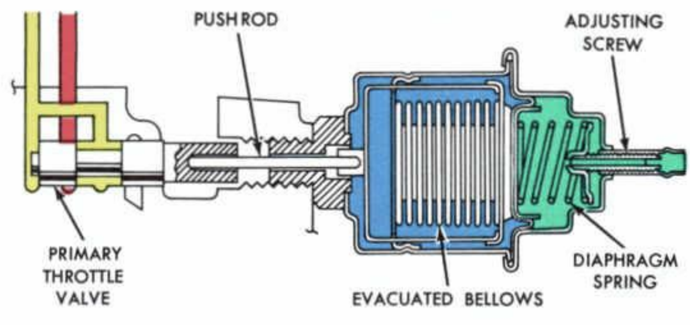


Fig. 56—Altitude-Compensated Diaphragm Unit

decreases by about one inch Hg. for each 1,000 feet altitude increase. The bellows decreases throttle pressure at higher altitude to make the shift feel comparable to lower altitude. The engine power loss at high altitude is offset by a lower throttle pressure and the shifts remain smooth.

PRESSURE BOOSTER VALVE

When the torque load is high, more control pressure is required to apply and hold the clutches and band. To increase the control pressure, throttle pressure is routed under two faces of the **pressure booster valve** (Fig. 57). At about 17 inches of vacuum or 10 psi throttle pressure, the pressure booster

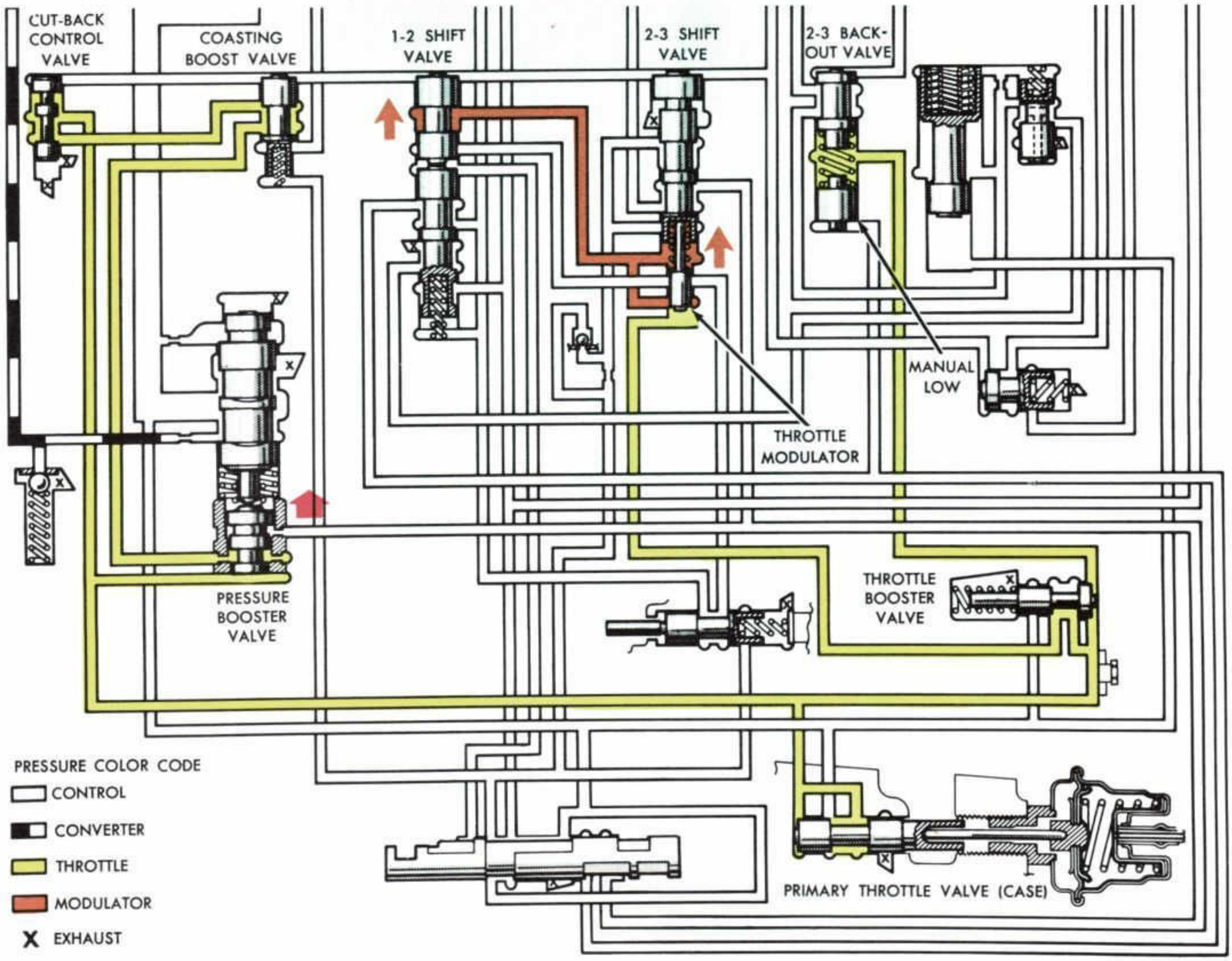


Fig. 57—Throttle Pressure System

valve is forced up and adds to the regulator valve spring force. Thus, it takes more pressure to balance the regulator valve and control pressure increases.

THROTTLE MODULATOR VALVE

Throttle pressure also is routed to the throttle booster valve and under the throttle modulator valve and 2-3 back-out valve. When the throttle pressure reaches about 25 psi, the throttle modulator valve is pushed up and becomes a balanced regulating valve. The modulated throttle pressure is a reduced pressure that is proportional to throttle pressure. It acts on a differential area on the 1-2 shift valve and on the end of the 2-3 shift valve to oppose governor pressure and delay the upshifts.

At throttle pressures lower than 25 psi, only a light spring holds the 1-2 shift valve train up, and the 1-2 upshift occurs as soon as the governor cuts in. To delay the 1-2 upshift takes a fairly heavy foot on the gas.

CUT-BACK CONTROL VALVE

On the way to the pressure booster valve, throttle pressure is routed through the cut-back control valve. Throttle pressure exerts a force on the cut-back control valve that holds it up against governor pressure.

At some point between 10 and 30 mph, governor pressure overcomes throttle pressure and shifts the cut-back control valve down (Fig. 58). With a light foot on the throttle, this shift occurs at 10 mph when the governor cuts in; with a heavy foot, at

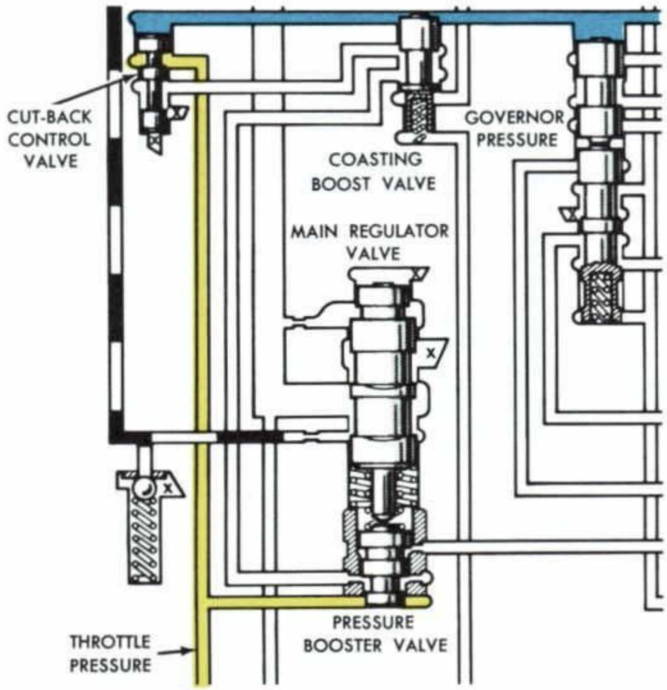


Fig. 58—Cut-Back Control Valve Operation

a higher speed. In most cases, the control pressure cut-back occurs before the 1-2 shift comes in.

When the cut-back control valve shifts, throttle pressure is cut off from the upper passage to the pressure booster valve, and control pressure decreases.

THROTTLE BOOSTER VALVE

We've said that throttle pressure increases proportionately as vacuum decreases. Unfortunately, at more than 50 percent throttle opening, we don't get the same rate of vacuum change as at less than 50 percent throttle. To compensate for this, the throttle booster valve provides an increased pressure at the higher throttle openings.

Up to about 65 psi throttle pressure (4½ inches of vacuum), throttle pressure passes around and through the throttle booster valve without affecting it (Fig. 57). At 4½ inches of vacuum, throttle pressure on the end of the booster valve shifts it to the left (Fig. 59). The throttle pressure passage between the valve lands is cut off and control pressure is cracked into the space between the lands. Now the throttle booster valve is a balanced valve, and sends boosted throttle pressure to the modulator valve instead of throttle pressure. This causes a higher modulated throttle pressure to delay the upshifts.

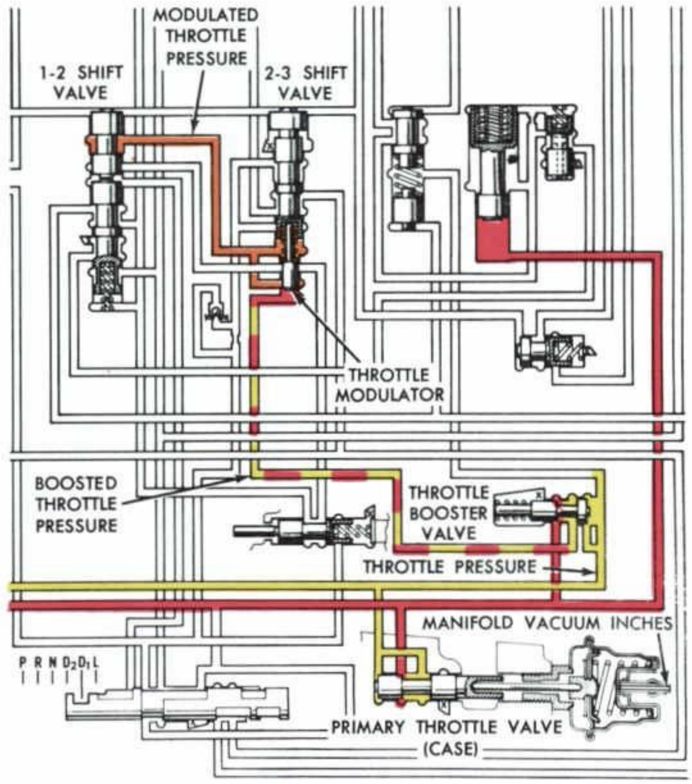


Fig. 59—Boosted Throttle Pressure System

KICKDOWN SYSTEM

The function of the kickdown system is very simple. It overrides the governor's control of maximum shift speeds to force downshifts at higher speeds or to delay upshifts longer than full-throttle pressure would delay them. A mechanical connection to the accelerator linkage shifts the downshift valve when the accelerator is depressed through the detent.

Downshift Valve

The downshift valve is supplied control pressure from the "D1" passage of the manual valve in D1 and D2 ranges only (Fig. 45). Shifting the downshift valve directs this control pressure under the 2-3 shift valve and to a differential area of the 1-2 shift valve to move one or both of the valves and downshift the transmission (Fig. 60). The driver can "kickdown" to second up to about 65 mph and to low up to about 30 mph.

SECOND-AND-HIGH GEAR LOCKOUT SYSTEM

We have one more system-within-a-system to study, and that's the second-and-high gear lockout

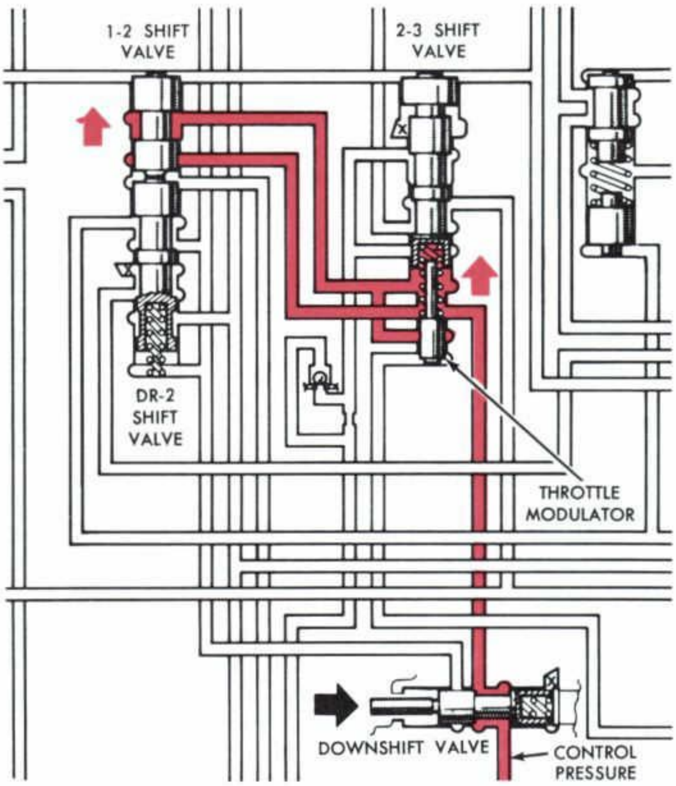


Fig. 60—Kickdown System

system. This system operates in low-and-reverse gear partly through the kickdown system. It is charged from the "L-R" passage of the manual valve (Fig. 61).

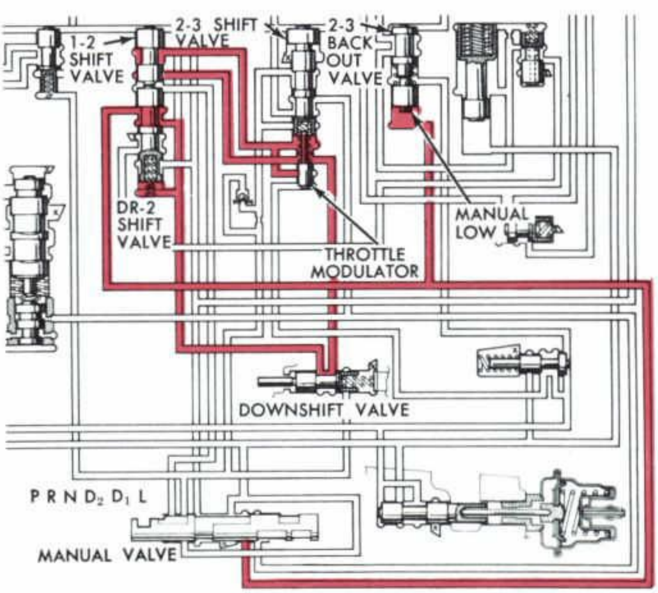


Fig. 61—Second-and-High Gear Lockout System

Full control pressure is directed under the DR2 valve and the 2-3 back-out valve. Through the kickdown system (downshift valve), control pressure also is effective under the 2-3 shift valve and on the differential areas of the 1-2 shift valve. Thus, all the shift valves are prevented from causing an upshift.

SUMMARY

Now, before we study the complete system in the different ranges and operating conditions, here's a quick review of the individual systems.

System	Figure Number	Function
Main Control Pressure	36	Supply and regulate fluid pressure.
Converter and Cooler	33	Supply converter and gear train lube and cooling.
Throttle Pressure	56	Engine load input to hydraulic control. Delay upshifts and increase control pressure.
Boosted Throttle Pressure	59	Compensate for lower rate of vacuum change above 50 percent throttle opening.
Shift Control Supply	45	Control pressure to downshift valve, 2-3 shift valve and coasting boost valve.
Forward Clutch and Governor Supply	38	Supply forward clutch and governor; and supply servo apply system.
Governor—No Pressure	49	Permit 3-1 downshift.
Governor—Above 10 mph	52	Road speed signal to hydraulic control. Cause upshifts and decrease control pressure.
Intermediate Servo Apply	42	Apply band in second gear.
Reverse-and-High Clutch Apply	41	Apply clutch and release servo.
Kickdown	60	Override automatic upshift.
Second-and-High Gear Lockout	61	Prevent shift valve movement in low and reverse.
Reverse Booster	41	High control pressure in reverse.
First Gear Lockout	39	Second gear start in D2.
Low-and-Reverse Clutch Apply	40	Fill and apply clutch.

HYDRAULIC CIRCUIT DIAGRAMS

In going through the individual systems, we've studied the operation of all the hydraulic system valves except those involved in controlling shift quality. The operation of these valves involves a more complete picture of the operation of the system under various conditions. So let's shift our own gears now and take a look at some diagrams of the whole hydraulic system.

CONTROL PRESSURE RISE

Figure 62 shows the hydraulic control system operation during a control pressure check at 15 inches of vacuum.

The engine and transmission are at normal operating temperatures. The service and parking brakes are firmly applied. The selector lever is in D1 and the throttle is advanced to the point that the vacuum gauge reads 15 inches. The control pressure gauge reads between 70 and 78 psi.

As the throttle was advanced from 19 inches (idle) of intake manifold vacuum to 15 inches, throttle pressure rose from about 5 psi to about 20 psi. At about 17 inches of vacuum, throttle pressure rose to about 10 psi. At this pressure, primary throttle pressure, which is acting at two places on the pressure booster valve, exerted a strong enough upward force to move it upward against its spring. This upward movement compressed the booster valve spring and unbalanced the regulator valve. The regulator valve cut off or reduced the flow to sump and retained more of the pump's output to raise control pressure and restore its balance.

At 15 inches of vacuum, a throttle pressure of about 20 psi is required to balance the throttle valve. At a throttle pressure of 20 psi, a control pressure of about 74 psi is required to balance the control pressure regulator valve.

With the throttle pressure below 65 psi, we do not have a boosted throttle pressure and the primary throttle valve supplies the throttle modulator valve. Now, suppose that while still holding the car from moving in D1 range, we open the throttle for a pressure check at less than one inch of vacuum (Fig. 63). The throttle booster valve is operating now and puts out a boosted throttle pressure which is transmitted to the modulator valve in place of throttle pressure. At the same time, throttle pressure has risen to around 80 psi and control pressure is over 100 psi (Fig. 55).

Of course, there is still no governor pressure because the car is not moving.

FIRST GEAR—D1

Figure 64 shows the operation of the system at 15 mph in D1 range with the accelerator at about half-throttle. Manifold vacuum is about 5 inches.

With the selector in D1, the forward clutch and governor supply system and the shift control supply system are charged. The front clutch is applied and control pressure is routed to the governor. Since the road speed is above 10 mph, the governor pressure system is operating and governor pressure is acting on top of the shift valves.

At 5 inches of vacuum, the throttle pressure is less than 65 psi, not enough to balance the throttle booster valve spring, so throttle pressure acts on the throttle modulator valve. The modulated throttle pressure, which began to build up at 25 psi throttle pressure, holds the shift valves up or downshifted against governor pressure. As road speed increases, governor pressure will increase (Fig. 65) to upshift the transmission.

Throttle pressure acting on the cut-back control valve holds this valve up against governor pressure too. So throttle pressure is effective at both passages to the pressure booster valve, holding control pressure to about 130 psi. In other words, the control pressure cutback (Fig. 66) has not occurred yet, and throttle pressure will prevent it up to 30 mph with a heavy torque demand.

SECOND GEAR—D1

Figure 67 shows the hydraulic control system operation in second gear, at moderate throttle, and at a road speed of 20 mph in D1 range.

If we associate this operation with the operation in first gear, we can put together the following explanation.

The throttle opening is still something under 50 degrees. This we know, because the throttle booster valve is still in its rest position. Engine intake manifold vacuum is still less than 14 inches and throttle pressure is at least 25 psi, because the throttle modulator valve is still open.

The 1-2 shift occurred when governor pressure force, acting downward on the 1-2 shift valve moved the 1-2 shift valve and DR2 valve down. Control pressure flowed through the DR2 valve and charged the intermediate servo apply system.

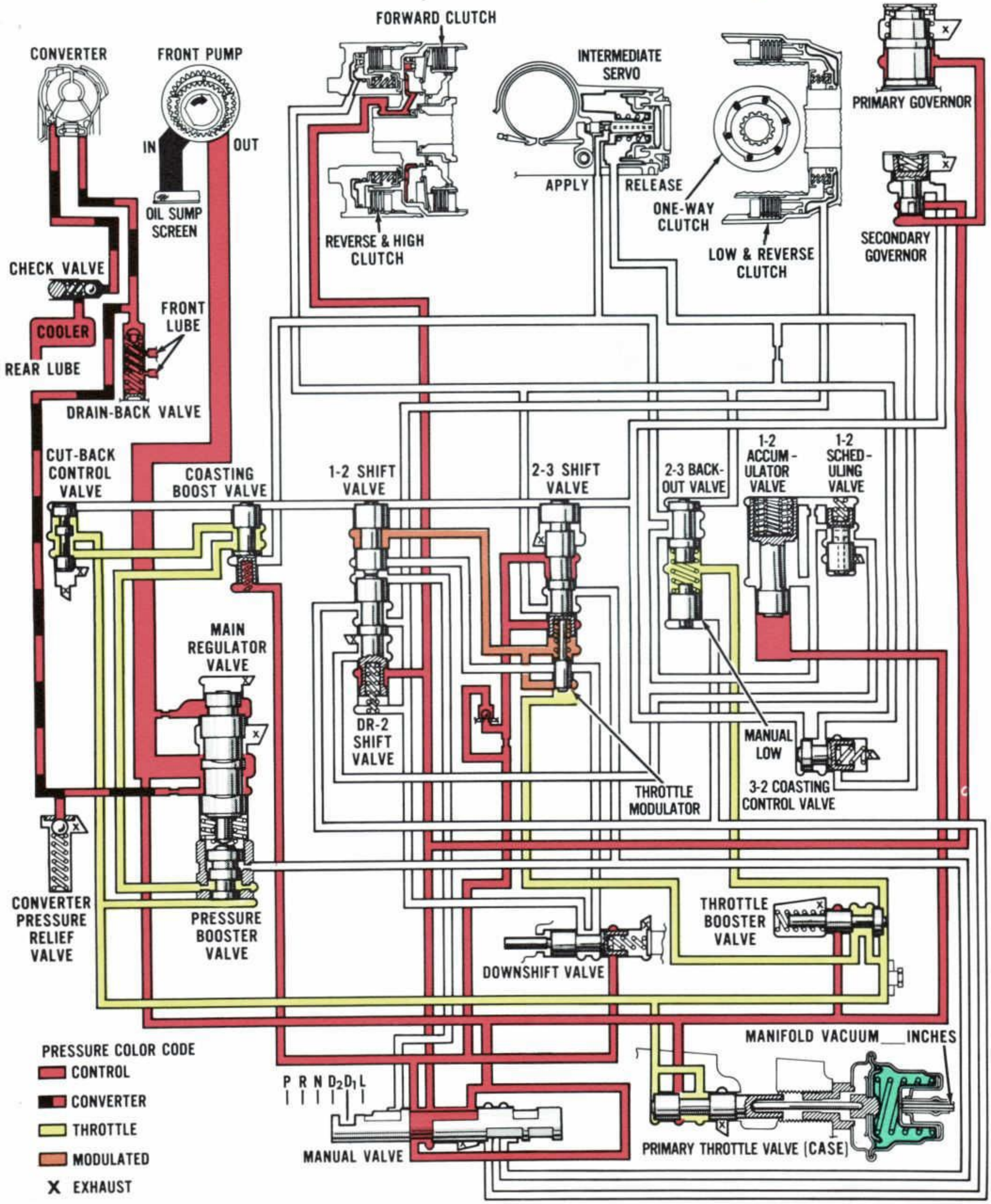


Fig. 62—Transmission Pressures at 15 Inches of Vacuum

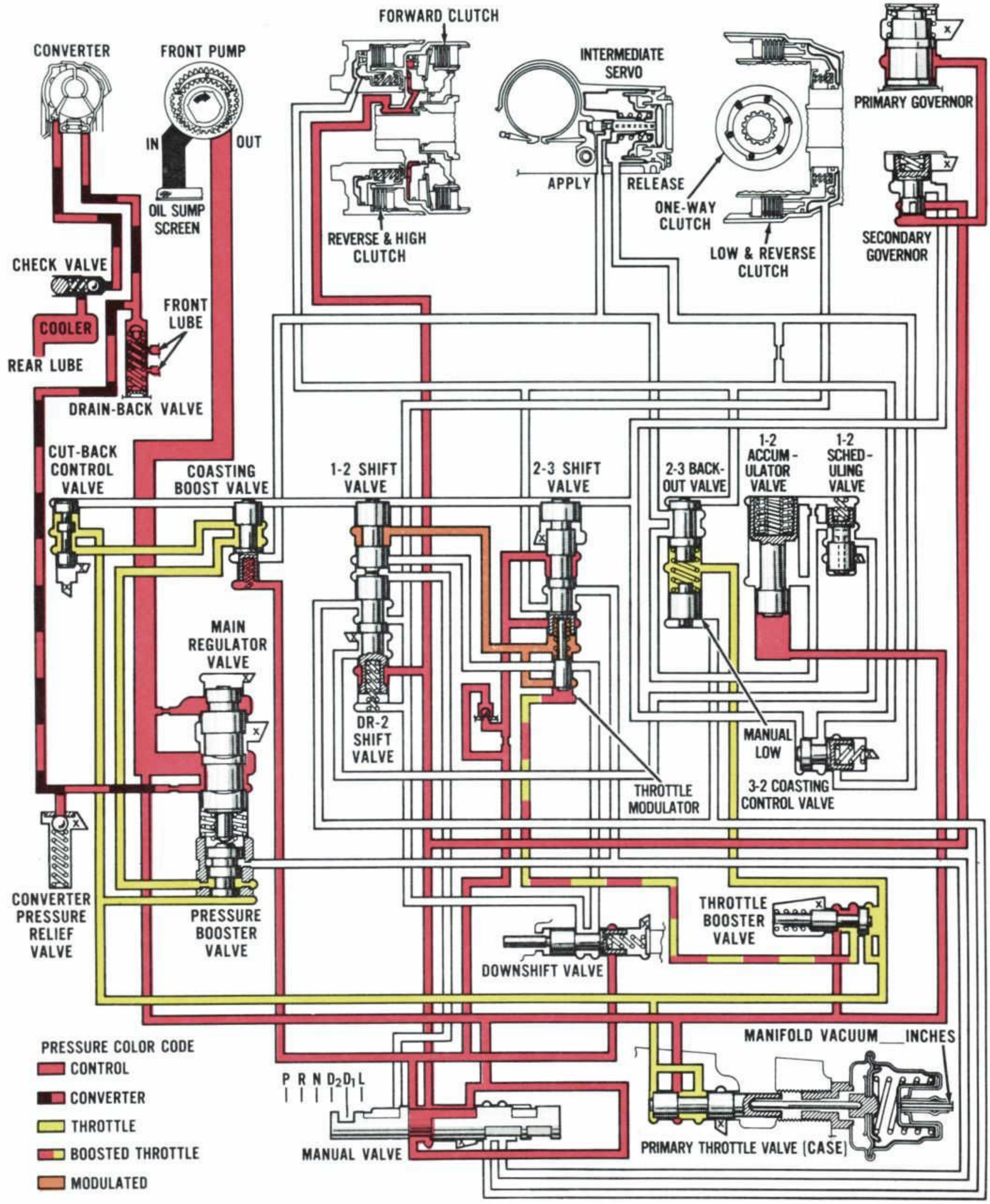


Fig. 63—Transmission Pressures at Less Than One Inch of Vacuum

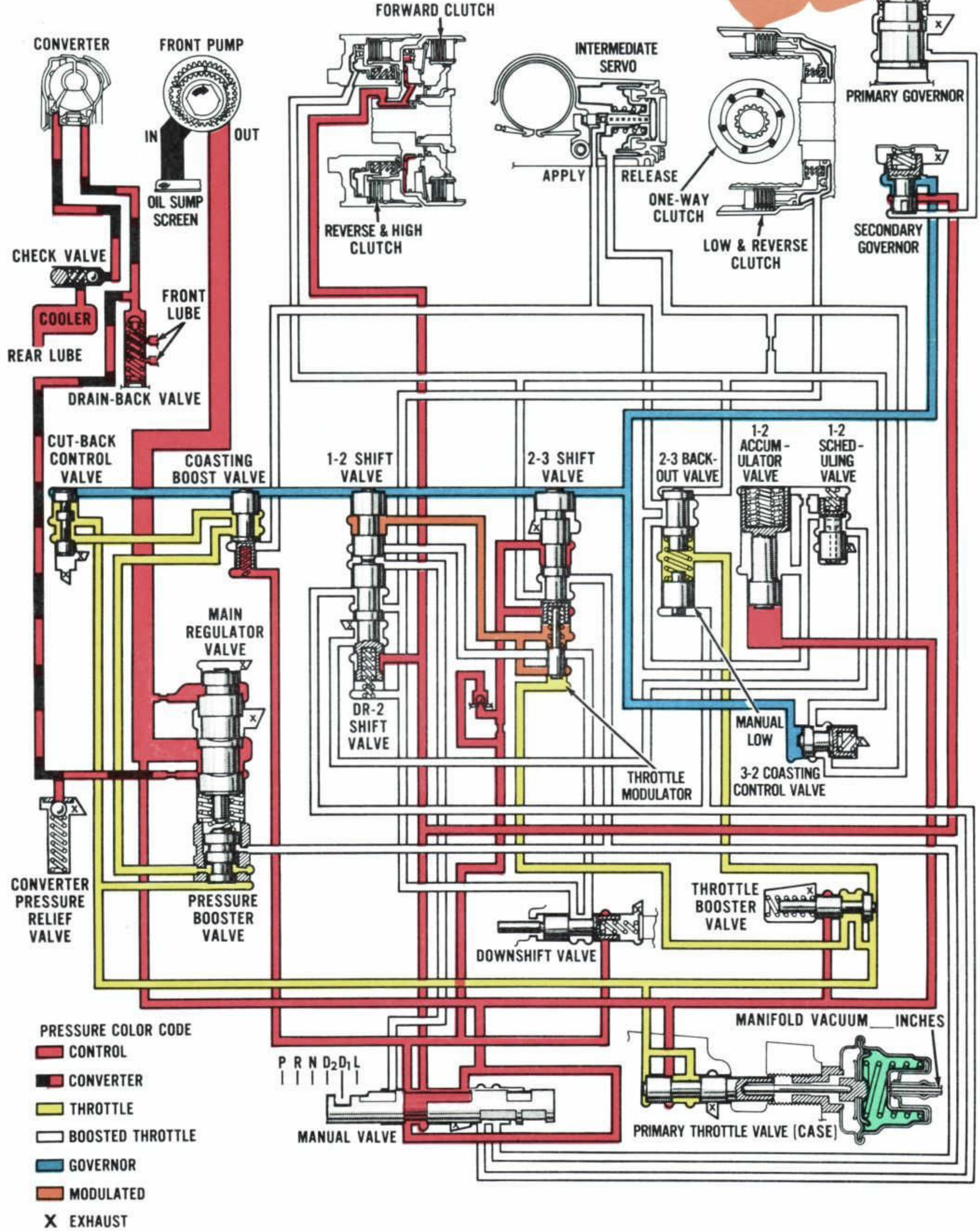


Fig. 64—First Gear D1 at 15 mph

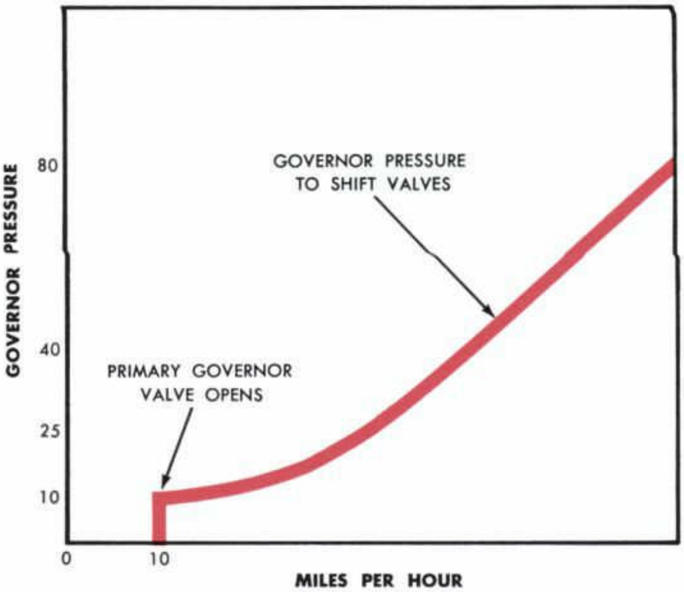


Fig. 65—Governor Pressure Variation at Road Speed

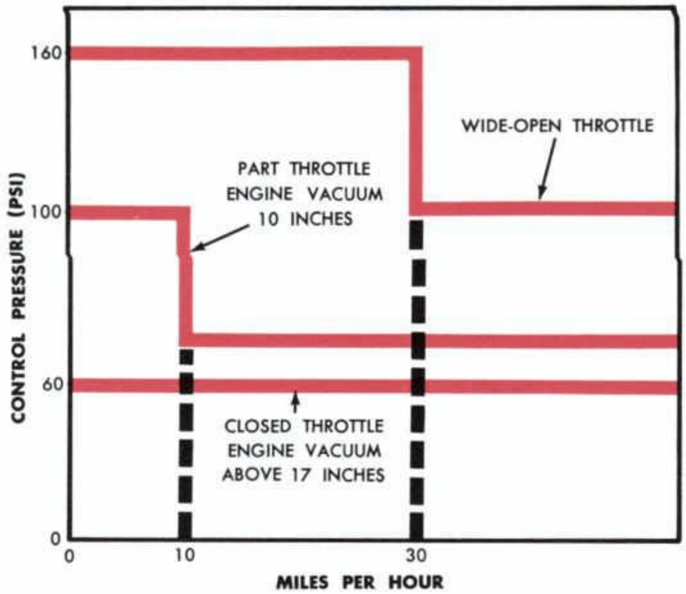


Fig. 66—Control Pressure Cutback

At 20 mph and at half-throttle, the cut-back valve has been forced down by governor pressure. Control pressure has decreased because throttle pressure is effective at only one passage of the pressure booster valve.

As soon as the band came on, the low-and-reverse planet carrier started turning clockwise (from the front). This clockwise rotation unlocked the one-way clutch and the transmission is now in second gear.

1-2 SCHEDULING VALVE AND ACCUMULATOR VALVE

The 1-2 scheduling valve and the accumulator valve are placed in the servo apply system to cushion the 1-2 upshift by controlling the rate at which the band applies. You could compare this to engaging the clutch in a car with a manual transmission. The driver lets the pedal out rapidly until the clutch starts to apply, then slows down the travel to cushion the final lockup.

Before the servo apply system is charged, control pressure is effective only under the 1-2 accumulator valve. This is a direct connection from the main pressure control system in all ranges. When the DR2 valve moves to charge the servo apply system, control pressure is routed through the 1-2 scheduling valve to apply the servo (Fig. 68a). Control pressure also is routed through a drilled passage in the 1-2 scheduling valve to the bottom of the valve, and to the differential areas between the lands of the accumulator valve. Then, there is an orificed connection to the spring ends (top) of both valves.

Accumulator Valve Moves Down

The orifice prevents pressure from building above the valves for an instant until the band comes in contact with the drum. Then, pressure is transmitted through the orifice (Fig. 68b) and, added to spring force, begins to move the accumulator valve down. Fluid then flows through the orifice, resulting in a lower pressure **above** the valves while the accumulator valve is moving down.

Balanced Valve

Now the 1-2 scheduling valve becomes a balanced valve. Pressure under the valve balances against spring force, plus the lower pressure above the valve. The lower land of the valve restricts the flow from the DR2 valve to the servo and opens a passage to sump to maintain the balance.

In this way, the 1-2 scheduling valve regulates to reduce the intermediate servo apply pressure until the 1-2 accumulator valve has fully bottomed in its bore.

Valves Bottomed

When the accumulator valve is bottomed, there can no longer be any flow through the orifice. Therefore, pressure equalizes throughout the servo apply system and the springs hold both valves down (Fig. 68c). Full control pressure is then effective on the servo piston.

Figure 69 shows how pressure rises in the servo apply line during the 1-2 shift.

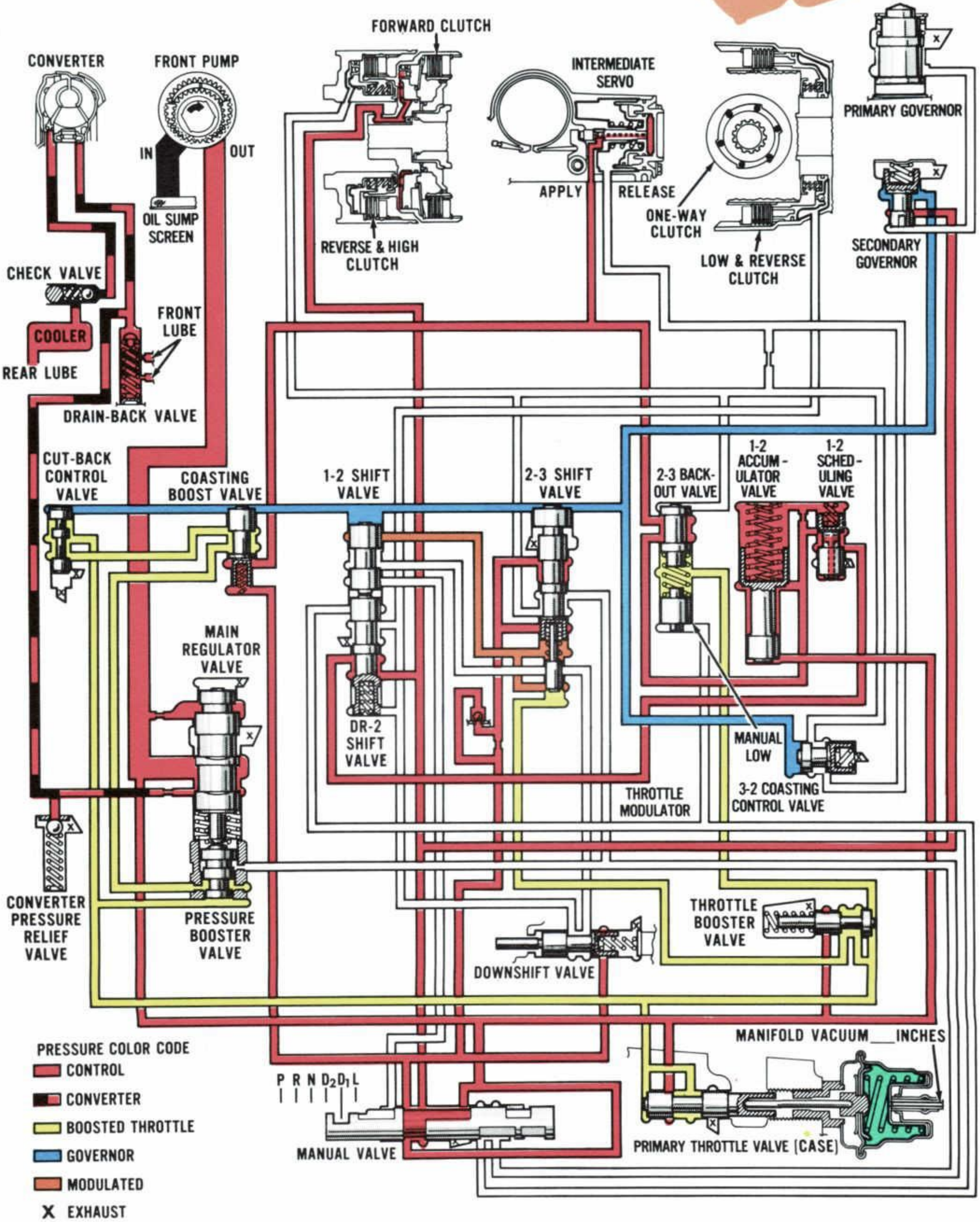


Fig. 67—Second Gear D1 at 20 mph

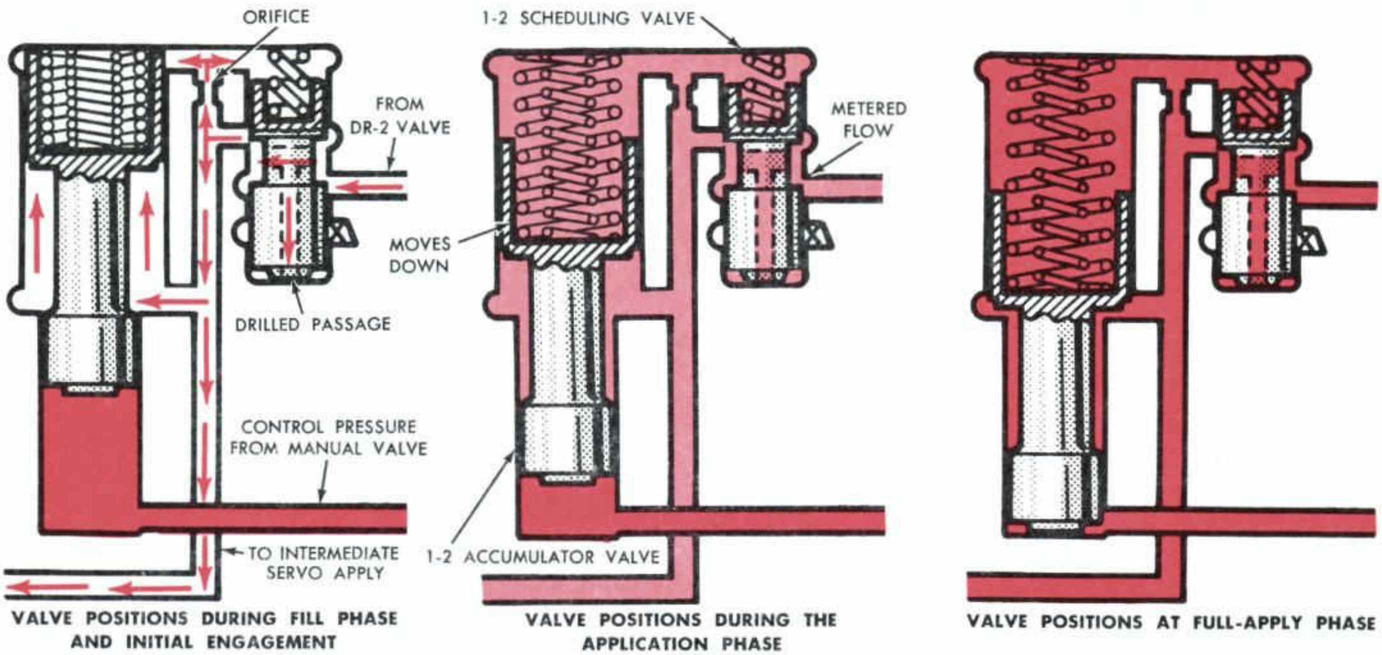


Fig. 68—1-2 Accumulator Valve and 1-2 Scheduling Valve

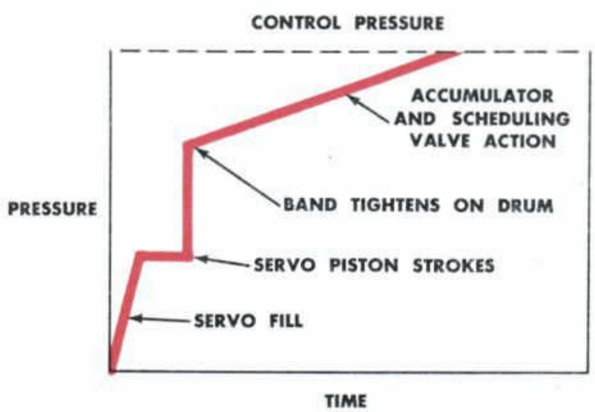


Fig. 69—Pressure Rise on 1-2 Shift

HIGH GEAR—D1

To get the transmission from intermediate (second) gear to high, the intermediate band must be released, and the reverse-and-high clutch must be applied. When the governor pressure force acting down at the 2-3 valve (Fig. 70), becomes stronger than the combined spring and modulated throttle pressure forces acting upward at the other end, the 2-3 shift valve is forced down.

Control pressure can now flow through the 2-3 valve to charge the reverse-and-high clutch apply system. Remember that when this system is charged, there is always release pressure on the servo, so the band is released. With the band released and both clutches applied, the transmission is in high gear.

SMOOTHING THE 2-3 UPSHIFT

In intermediate gear, the forward clutch and the intermediate band are applied. In the transmission gear train, the front ring gear is driving, the load is on the planet carrier, and the sun gear is stationary. There is a reaction force working at the sun gear trying to turn it counterclockwise (from the front).

To get the transmission into high gear, the sun gear will have to start turning clockwise and come up to the same speed as the ring gear. To get the sun gear turning, the reverse-and-high clutch applies and starts to drive the sun gear through its drum and the input shell. At the start of the shift, the drum, the shell and the sun gear are being held stationary by the intermediate band. A smooth shift requires, therefore, that the band release be timed precisely with the clutch application. If the band releases before the clutch applies, the sun gear will be driven in a counterclockwise (from the front) direction and the transmission will be in neutral.

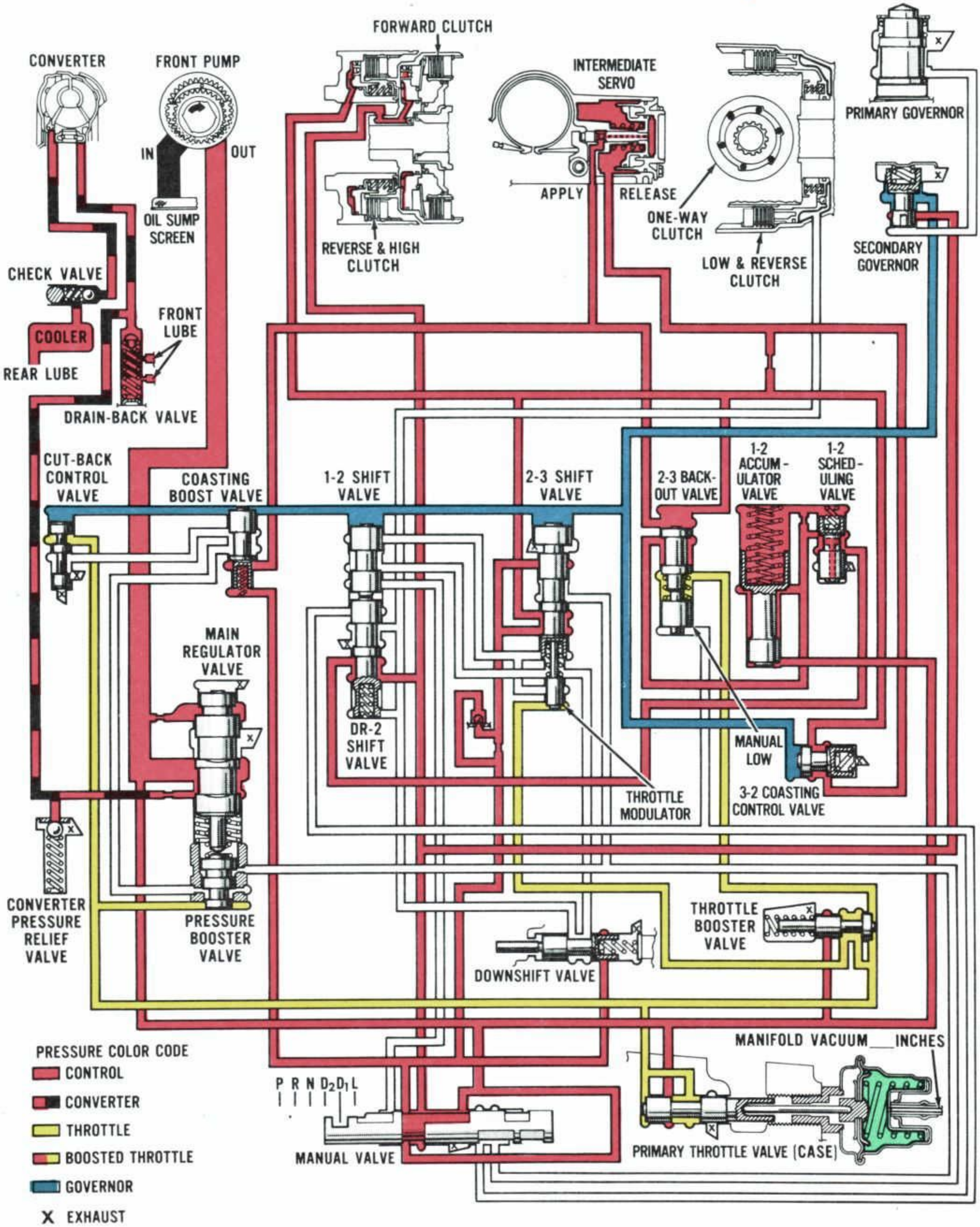


Fig. 70—High Gear—D1

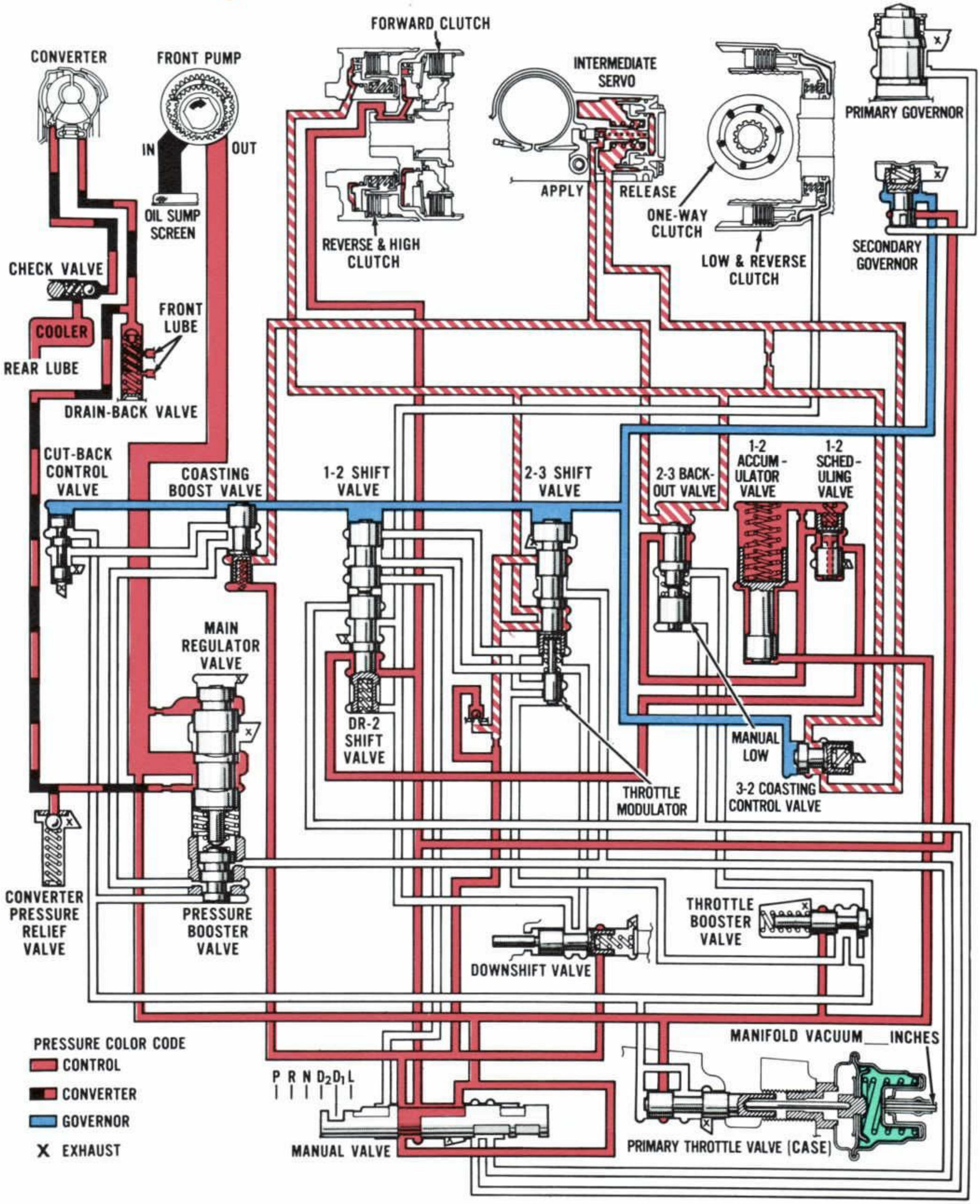


Fig. 71—2-3 Back-Out Shift

This is often referred to as a "buzz-up" during upshift. This "buzz-up" describes the sudden increase in engine crankshaft speed, which results from a suddenly unloaded engine.

If the clutch applies before the band releases, the transmission will be "locked" into two gears at the same time. The clutch and band are now "fighting" each other. The clutch is trying to start the drum rotating and the band is trying to hold it stationary. This condition is often called "lock-up" or "tie-up" during the upshift. It causes a harsh shift.

Orifice in Line

When the 2-3 shift valve moves down, control pressure flows through an orifice, to and through the 2-3 valve, to the release side of the intermediate servo, and to the reverse-and-high clutch (Fig. 70).

The rate of pressure buildup in the servo release and clutch apply line will vary with throttle opening and road speed, because control pressure varies with throttle pressure and road speed.

The orifice and adjusted control pressure cause a servo release and clutch apply pressure buildup rate, which provides smooth upshifts at a **steady** throttle setting. At steady throttle, engine power is flowing through the transmission and the shift is a "power-on" shift.

Should the driver release the throttle after the 2-3 shift has started, but before it has been completed, the shift could be harsh. With this sudden reduction in engine torque flow, there might be enough pressure in the servo release and clutch apply line to engage the clutch, but not enough pressure to release the servo. Here we could have a clutch and band "fight." To prevent this condition, the 2-3 back-out valve comes into operation (Fig. 71).

2-3 BACK-OUT VALVE

With zero primary throttle pressure, a servo release and clutch apply pressure of about 9 psi will push the 2-3 back-out valve down. As the 2-3 back-out valve comes down, it does two things. First, it cuts off control pressure flow to the apply side of the servo. Second, it opens a passage so that the apply pressure, which is trapped between the back-out valve and the servo piston, can now mix with the incoming servo release and clutch apply pressure. This causes servo apply and release pressures to become equal, and now the servo return spring can move the servo piston and release the band. A clutch and band "fight" has been prevented by the 2-3 back-out valve.

SECOND GEAR—D2

When the selector lever is moved to D2 (Fig. 72), the manual valve charges the "D2", "D1", and "D" passages with control pressure.

First Gear Lockout

The "D2" passage is the first gear lockout system. It routes pressure between the DR2 valve and 1-2 shift valve and forces the DR2 valve down. With the DR2 valve down, the servo apply system is charged from the forward clutch and governor system ("D" passage). (The accumulator valve and scheduling valve are bottomed in their bores.)

In D2, the one-way clutch gets no chance to engage. As long as the intermediate band and forward clutch are applied (second gear) or the forward and reverse-and-high clutch are applied (high gear), the low-and-reverse planet carrier must turn clockwise (from the front). In other words, first gear is locked out.

Shift Control Supply System

In D2, the transmission will upshift to high and downshift only to second because of the first gear lockout. Control pressure for the 2-3 upshift and 3-2 kickdown is supplied from the "D" passage (shift control supply system).

HIGH GEAR—D2

High-gear operation in D2 is identical with high gear D1 (Fig. 70), except for the control pressure force working at the top of the DR2 valve. With this force acting, the transmission can downshift to second gear only.

CLOSED THROTTLE DOWNSHIFT—D2

In a closed throttle coastdown in D2 (Fig 73), the transmission stays in high gear until governor pressure exhausts at about 10 mph. With no governor pressure, the 2-3 shift valve moves up and exhausts the reverse-and-high clutch apply pressure and the intermediate servo release pressure.

The intermediate servo apply pressure system is still charged and applies the band. The DR2 valve is down and locked there by control pressure from the manual valve in its D2 position. Since the DR2 valve cannot move up, the transmission downshifts to second gear.

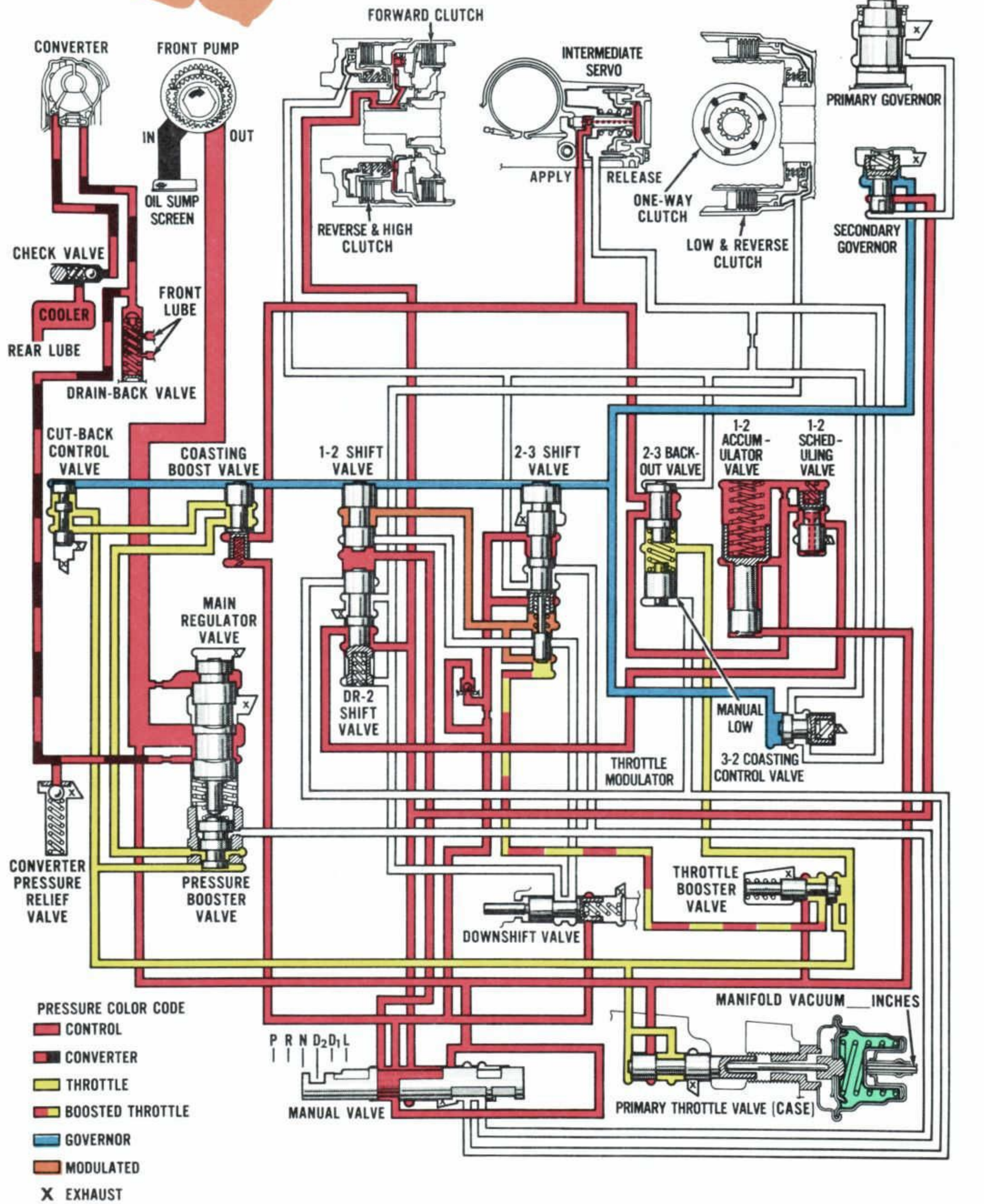


Fig. 72—Second Gear—D2

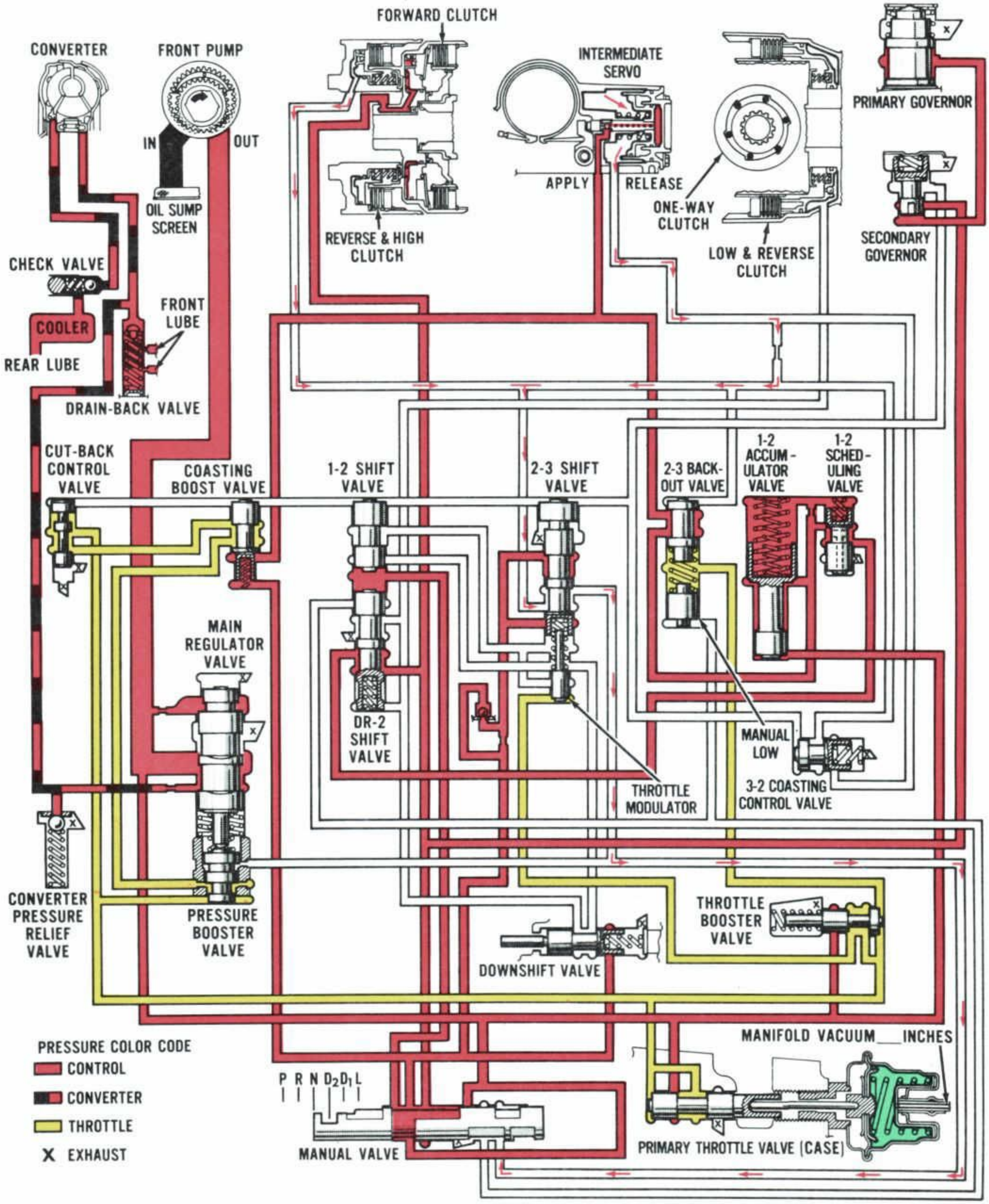


Fig. 73—Closed Throttle Downshift—D2

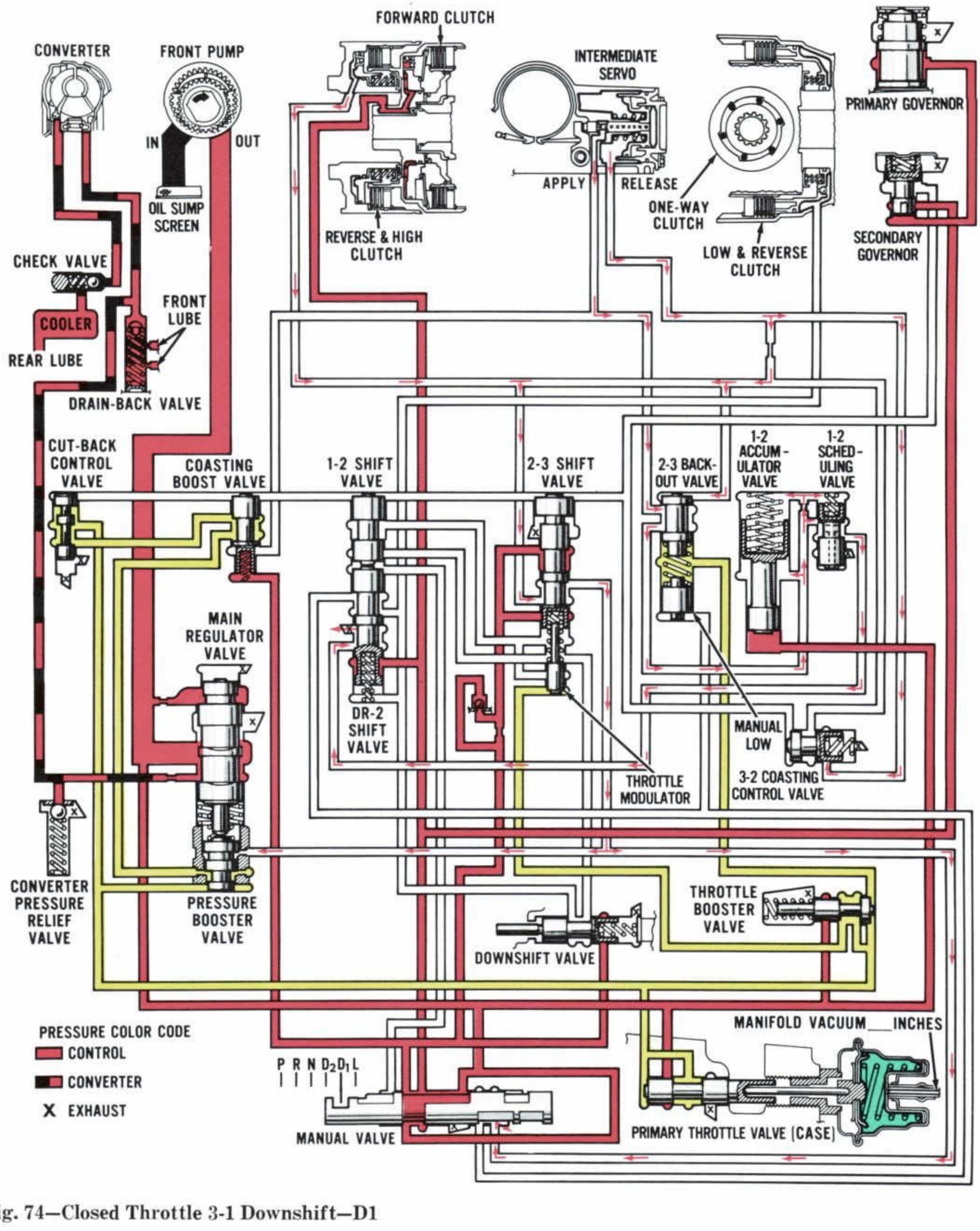


Fig. 74—Closed Throttle 3-1 Downshift—D1

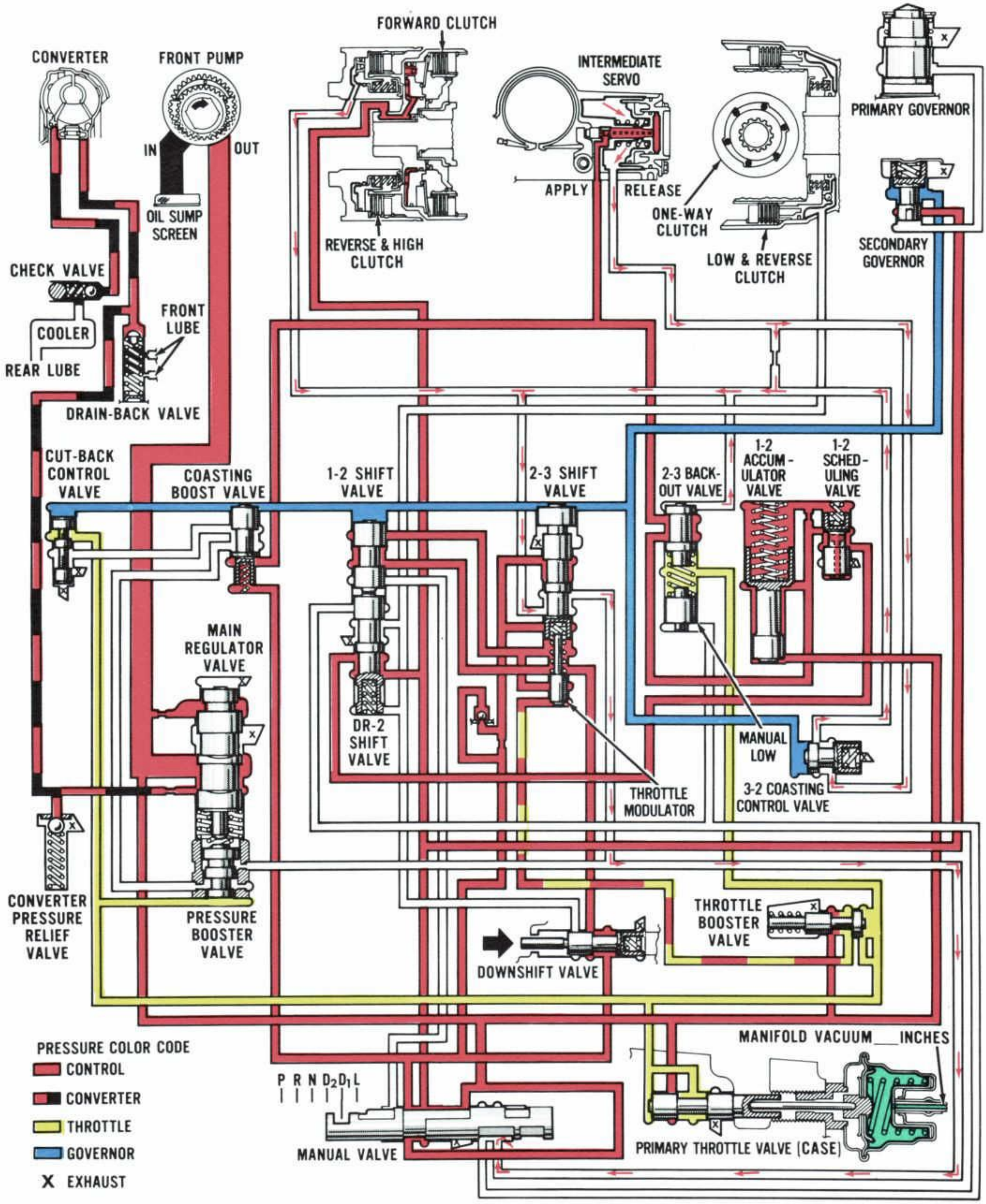


Fig. 75—3-2 Kickdown

Notice there is no modulated throttle pressure. Throttle pressure is only about 5 psi at closed throttle.

CLOSED THROTTLE DOWNSHIFT—D1

Coasting down in D1, the transmission shifts from high gear directly to low. Again, there is no modulated throttle pressure, so governor pressure holds the shift valves down until the governor pressure exhausts at 10 mph (Fig. 74). Then both shift valves move up together exhausting the servo apply and reverse-and-high clutch apply systems.

Only the forward clutch is now applied, and the car is freewheeling if drive shaft speed is higher than engine crankshaft speed. If the engine speed is increased so that it is greater than drive shaft speed, the one-way clutch applies and the transmission is in first gear.

3-2 KICKDOWN

When the driver depresses the accelerator pedal through detent, the downshift valve is forced open (to the right) against its spring (Fig. 75). This permits control pressure to flow to the 2-3 shift valve and work against its lower face. At road speeds as high as 72 mph, this control pressure force is greater than governor pressure force and the 2-3 valve is forced up. When the valve goes up, the reverse-and-high clutch apply and intermediate servo release pressures are exhausted. The intermediate servo apply pressure, which has been in the servo during high-gear operation, can now apply the intermediate band and the transmission shifts to intermediate gear.

Notice that we have boosted throttle pressure acting on the throttle modulator valve because of the full-throttle opening. Of course, control pressure is at least as great as boosted throttle pressure, and combined with the spring, holds the modulator valve down while control pressure charges the modulator pressure lines.

The kickdown is shown in D1 range, so we know the road speed is above 30 mph and governor pressure on top of the 1-2 shift valve is holding the valve down against control pressure on the differential areas. The system would appear the same in D2 except for first gear lockout pressure between the 1-2 shift valve and the DR2 valve.

SHIFT POINT SPREAD

The 2-3 upshift can come in at a road speed as high as 80 mph though the downshift speed is limited to 72 mph. This spread in upshift and downshift speed is caused by a control pressure force acting in the 2-3 shift valve upper valley.

When the 2-3 shift valve is in its rest position in D1 or D2, control pressure flows into the upper valley of the valve. The face at the top of the valley is larger in area than the face at the bottom of the valley. This difference in face areas produces an up force on the 2-3 shift valve.

When the 2-3 shift valve moves down, flow to this upper valley is cut off and the pressure in the valley is exhausted at the manual valve.

The forces acting, therefore, during a through-detent upshift and downshift are not the same. The difference is the control pressure force in the 2-3 valve upper valley. This force is added and taken away to prevent the 2-3 shift valve from "hunting" with small changes in road speed and throttle opening.

3-2 Coasting Control Valve

The 3-2 coasting control valve controls the intermediate servo apply force to provide acceptable 3-2 downshifts under both coasting and "throttle-on" conditions.

During a 3-2 forced downshift (Fig. 75), the vehicle speed will be such that governor pressure will hold the 3-2 coasting control valve bottomed in its bore against its spring. In this position, intermediate servo release fluid exhausts through the coasting control valve and 2-3 shift valve during a 3-2 downshift, allowing a rapid apply of the intermediate band.

At the 3-2 coasting downshift speed, governor pressure is reduced to zero and the 3-2 coasting control valve is moved by spring force to the bottom of its bore (Fig. 73). This blocks the direct passage of intermediate servo release fluid to exhaust and requires that this fluid be exhausted through a controlling orifice. Therefore, the band application is cushioned during a 3-2 coasting downshift, resulting in a smooth shift.

KICKDOWN TO LOW

When kicking down below 30 mph in D1, control pressure from the downshift valve acting at the differential areas of the 1-2 shift valve can overcome governor pressure and move the shift valve up (Fig. 76). The spring then moves the DR2 valve up to exhaust the servo apply system and downshift to low. Otherwise, the system operation is the same as a 3-2 kickdown.

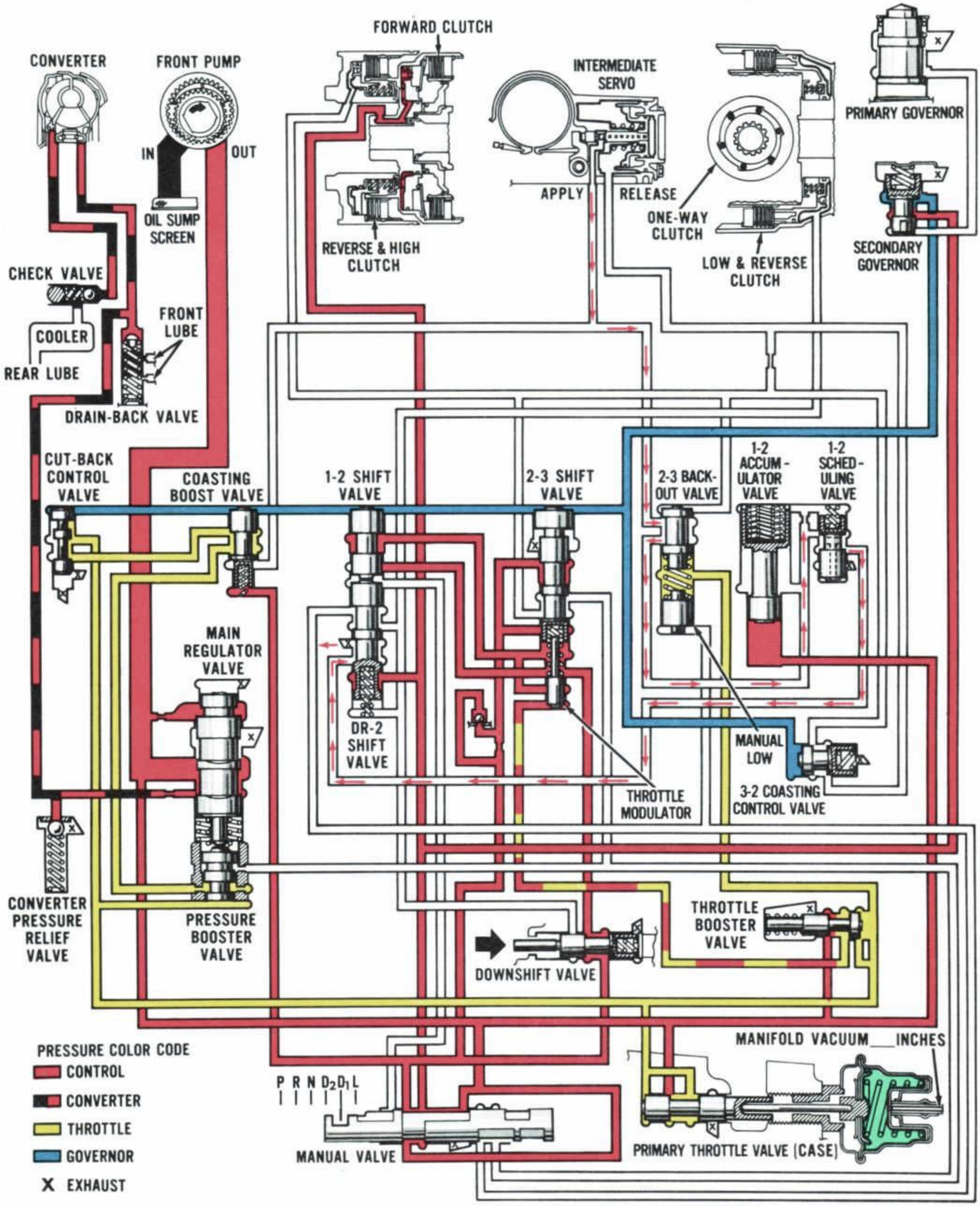


Fig. 76—Kickdown to Low

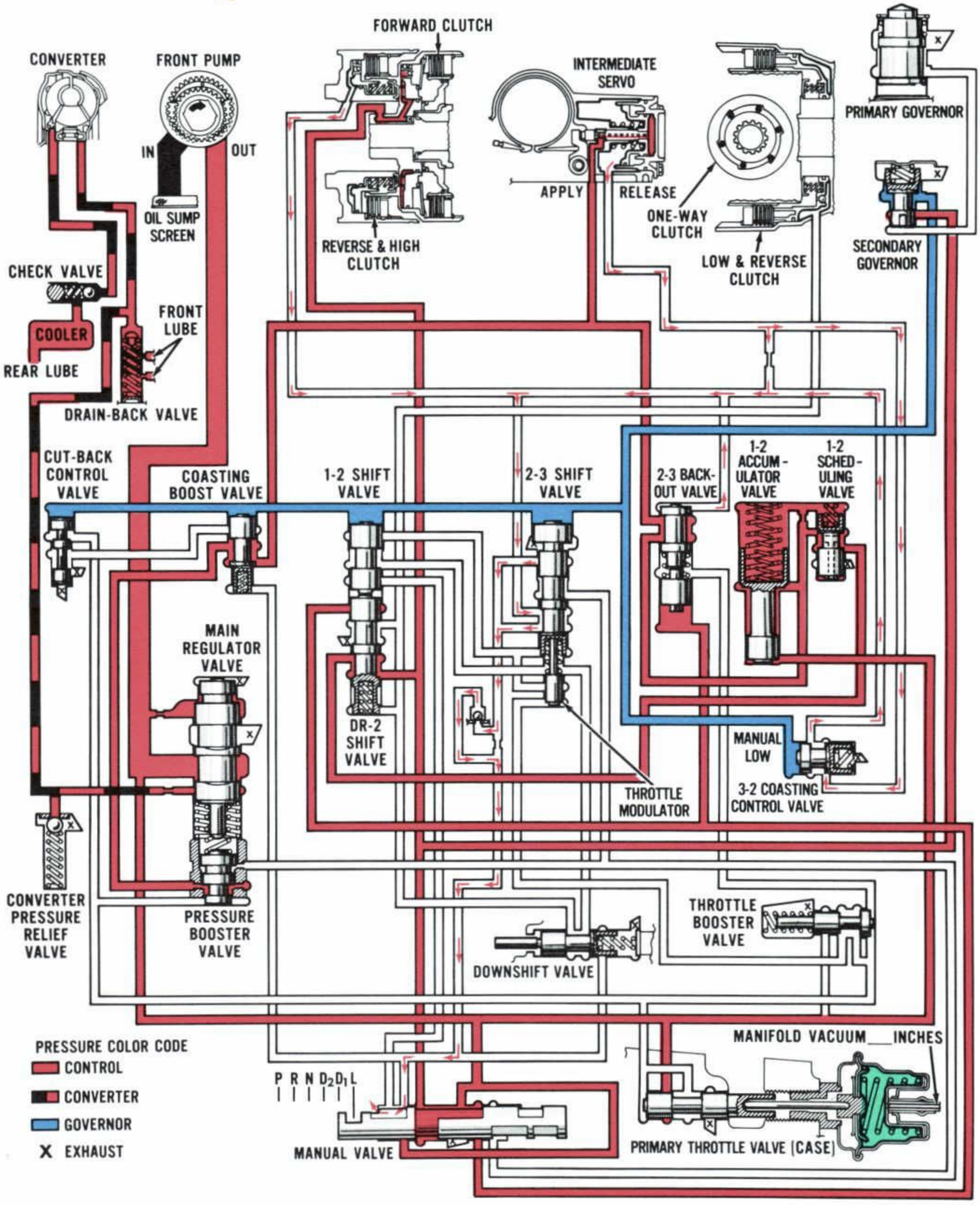


Fig. 77—Shift to Manual Low from High Gear

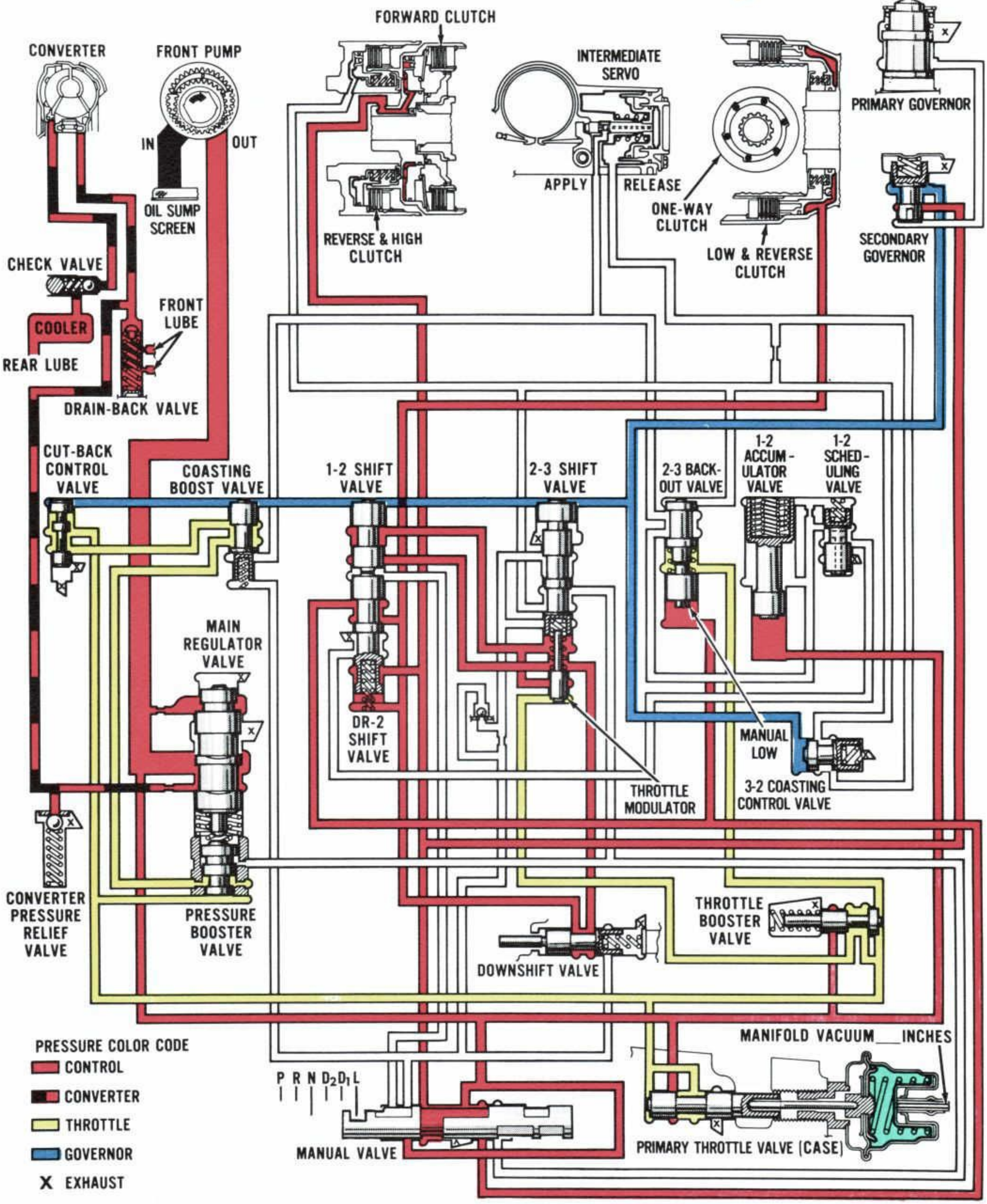


Fig. 78—Manual Low Start

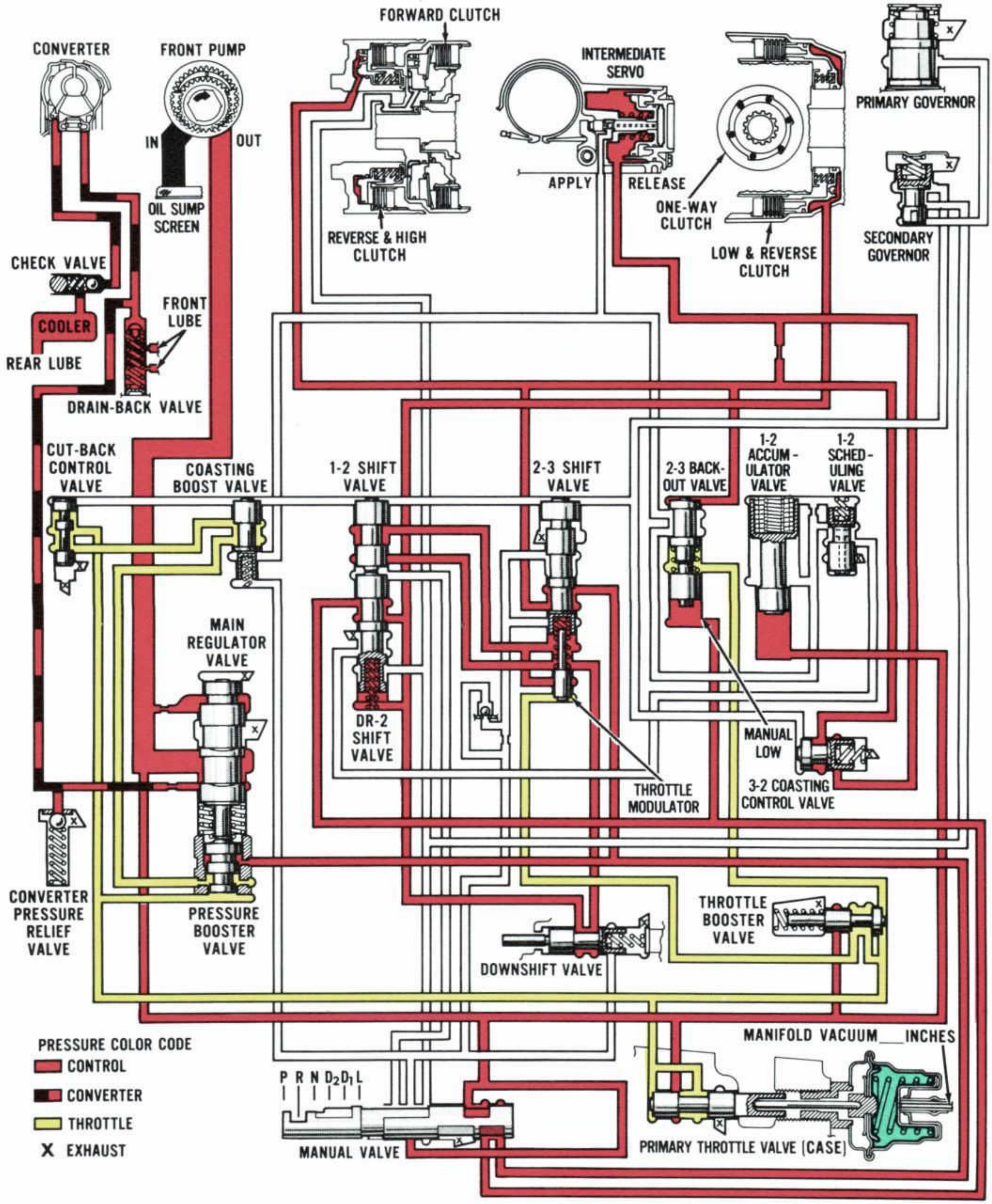


Fig. 79—Reverse

HYDRAULIC CONTROL SYSTEM

MANUAL LOW PLUG

The manual low ensures that the transmission will downshift to second gear anytime the driver shifts to manual low from high gear in D1 or D2.

In high gear (Fig. 70), the 2-3 back-out valve is down. When the selector lever is moved to L, control pressure from the manual valve "L-R" passage is effective under the manual low plug and forces the 2-3 back-out valve **up** (Fig. 77). At the same time, the "D1" passage which charged the reverse-and-high clutch system in high gear is now vented to sump at the manual valve. So the reverse-and-high clutch and the servo release pressures are relieved. The shift valves remain down because of high governor pressure.

Now, if the 2-3 back-out valve stayed down, the servo **apply** system also would be vented to sump through the passage at the top of the valve. Since the valve is up, though, the servo apply system stays under pressure. The band comes on, so the downshift is to second instead of low.

COASTING BOOST VALVE

Again comparing Fig. 70 and Fig. 77, we see that the control pressure which held the **coasting boost valve** up in D1 and D2 is exhausted at the manual valve in manual low. When the driver shifts from D1 or D2 high gear to manual low, governor pressure forces the coasting boost valve down. This opens a passage from the servo apply system to port full control pressure to the pressure booster valve and increases control pressure.

We need a very high control pressure on this shift because the band is self-de-energizing when the drum is turning clockwise, as it is in high gear. In other words, the drum rotation has a tendency to loosen the band by forcing the apply strut back against the servo piston. Less pressure is needed for 1-2 upshift, since the drum is turning counterclockwise and the band is self-energizing. (On the 3-2 kickdown, of course, throttle pressure is at maximum and adjusts line pressure to compensate for the self-de-energizing action of the band.)

Figure 77 shows the shift to manual low at closed throttle with no throttle pressure. If the throttle was open instead, throttle pressure would be effective under the throttle booster valve to further increase control pressure.

MANUAL LOW START

Comparing Fig. 77 and Fig. 78, you can see the difference between a start and a shift to L from D1 or D2. Starting in manual low, both shift valves are up and the "L-R" passage charges the low-and-reverse clutch and the second-and-high lockout system through the DR2 valve. Full control pressure now is effective under the DR2 valve; through the downshift valve and under the 2-3 shift valve; and at the differential areas of the 1-2 shift valve. The 1-2 shift valve train can't move then, so no 1-2 shift is possible. And even if the governor does not shift the 2-3 shift valve, nothing can happen because there is no control pressure to it.

REVERSE

In reverse (Fig. 79), the manual valve "L-R" passage charges the low-and-reverse clutch and the second gear lockout system. There is no control pressure to the governor and, therefore, no governor pressure on the shift valves. The 2-3 shift valve remains up and the manual valve "L" passage charges the reverse-and-high clutch system. So the low-and-reverse clutch and the reverse-and-high clutch are applied.

The "L" passage also charges the reverse pressure booster system, sending full control pressure to the pressure booster valve and raising control pressure.

Control pressure in reverse at less than one inch of manifold vacuum should be 230-252 psi.

Ball Check Valve

The steel ball valve in the low-and-reverse piston is there to provide a complete clutch apply oil leak-down so that clutch engagement will require a complete refill and thereby, a softer engagement.

NEUTRAL AND PARK

In both neutral and park, the manual valve blocks control pressure from all five of its passages. The only systems in operation at idle are the main control pressure system, the converter and cooler system, and the throttle pressure system.

SUMMARY OF VALVE FUNCTIONS

Again for review and for reference, here is a quick recap of the functions of each of the valves in the hydraulic control system.

Valve	Figure Reference	Function
Governor	49-52	Road speed signal.
Check valve	33	Prevents converter draining through cooler when engine stops.
Drain-back valve	33	Prevents converter draining through front lube when engine stops.
Cut-back control valve	57	Reduces control pressure as road speed increases.
Coasting boost valve	77	Boosts line pressure on manual low shift at closed throttle.
1-2 shift valve train (1-2 valve and DR2 valve)	43, 44	1-2 and 2-1 shift.
2-3 shift valve	46, 47	2-3 and 3-2 shift.
2-3 back-out valve	71	Prevents tie-up if driver backs off gas during 2-3 upshift.
1-2 accumulator and 1-2 scheduling valves	68	Cushions 1-2 upshift.
Manual low plug	77	Shifts to second gear on manual low shift from high gear in D1 or D2 above 10 mph.
3-2 Coasting control valve	73, 75	Cushions Servo on 3-2 coasting shift.
Converter pressure relief valve	33	Limits maximum pressure in converter to about 90 psi.
Main regulator valve	31	Regulates control pressure.
Pressure booster valve	41, 56	Increases control pressure for high torque output.
Throttle modulator valve	56	Provides decreased throttle pressure on shift valves to delay upshifts.
Downshift valve	60	Overrides automatic upshift.
Throttle booster valve	59	Increases throttle pressure above 50 percent throttle opening.
Manual valve	37	Directs control pressure to various systems, as required, for automatic control of gear train and shift quality.
Throttle valve	53	Engine load signal.

DIAGNOSIS AND ADJUSTMENT

In this section, you'll see how to apply your knowledge of the C6 transmission operation to diagnosing troubles and correcting them by adjustments whenever possible. Very often, the simple adjustments you'll make during this procedure will correct the complaint. Where the trouble isn't fixed by adjustments, the diagnosis guide will help you to locate it.

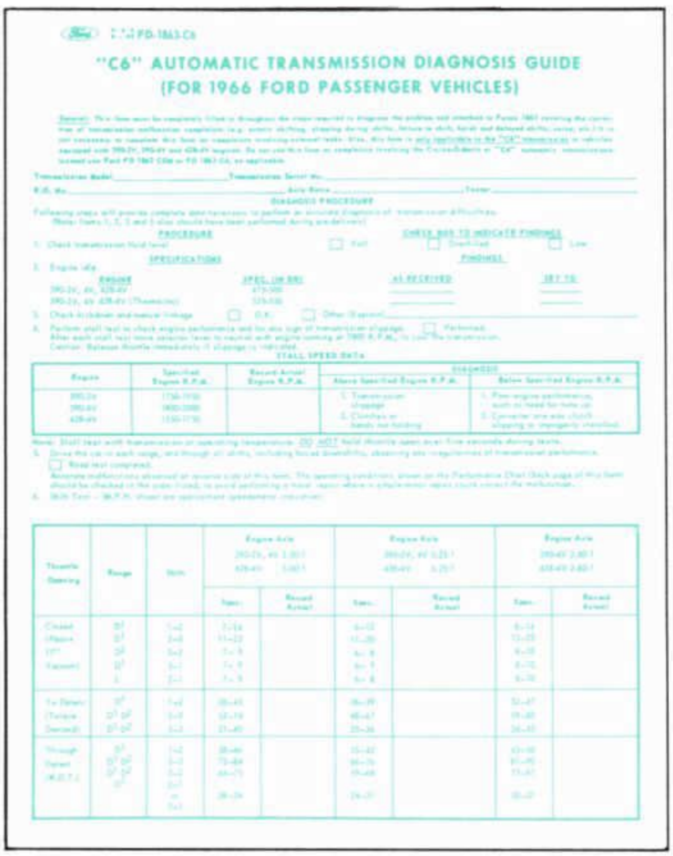
USE THE DIAGNOSIS GUIDE

One of the most important things to remember about diagnosis and adjustment is that there is a definite procedure to follow. Don't try to short-cut it. The diagnosis guide (Fig. 80) lists the steps in the order they should be taken to cover the likeliest causes of trouble first, and to eliminate **every** possibility that doesn't require opening the transmission before you start taking things apart. The guide also has all the necessary specifications for the tests and adjustments, and spaces to record your findings. On the backside, it lists the troubles you can run across, and the checks to make for each trouble—starting with the easiest and most likely. Use the guide as it is intended and you won't find yourself up a lot of blind alleys.

TRANSMISSION TESTER

To make your job easier, there is a new Automatic Transmission Tester available (Fig. 81). The tester includes a tachometer, pressure gauge and

Fig. 81—Transmission Tester


"C6" AUTOMATIC TRANSMISSION DIAGNOSIS GUIDE (FOR 1966 FORD PASSENGER VEHICLES)

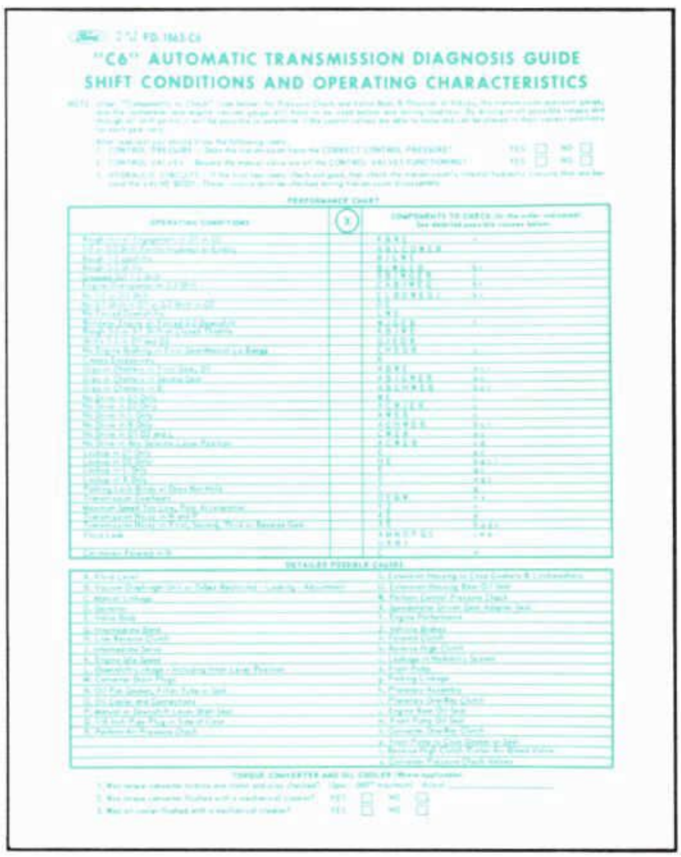

"C6" AUTOMATIC TRANSMISSION DIAGNOSIS GUIDE SHIFT CONDITIONS AND OPERATING CHARACTERISTICS

Fig. 80—Diagnosis Guide

vacuum gauge, with long enough wires and hoses to use the tester while in the driver's seat. A convenient bracket lets you hang the tester on the window for easy reading.

The tester connections are:

- **Tachometer Leads**—Distributor terminal on coil and ground.
- **Vacuum Gauge**—Tee into diaphragm vacuum line (Fig. 82).
- **Pressure Gauge**—Control pressure tap at left front of case (Fig. 83).

You'll need the tachometer almost immediately to check engine idle, but won't need the gauges until later when you may have to make the pressure tests.

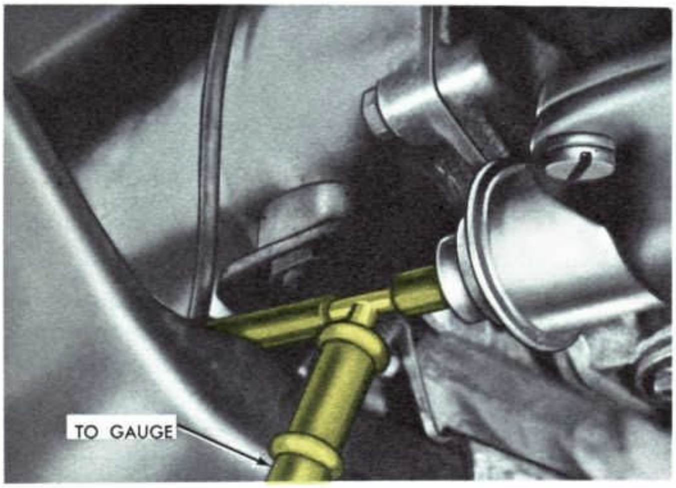


Fig. 82—Vacuum Gauge Connection

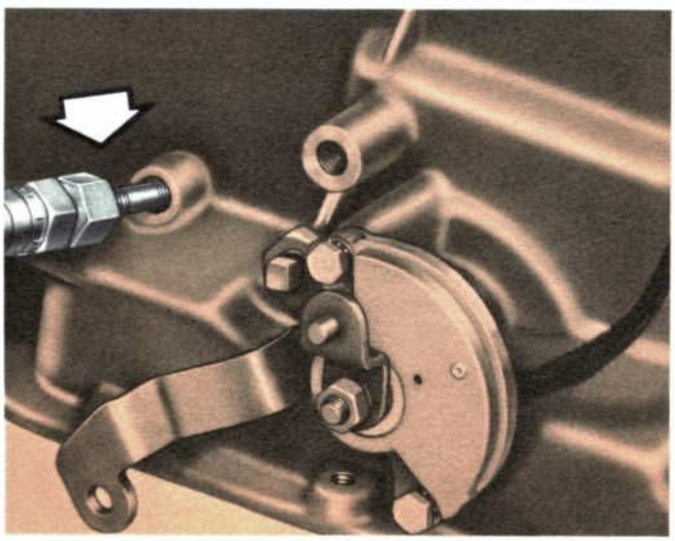


Fig. 83—Control Pressure Gauge Connection

PRELIMINARY CHECKS AND ADJUSTMENTS

CHECK THE FLUID LEVEL

It makes good sense to always check the fluid level and the condition of the fluid as the **first** step in your investigation of **any** automatic transmission complaint—for several reasons. It's easy to check, and many complaints are the direct result of poor fluid maintenance.

For example, too little fluid starves the hydraulic system and causes delay in clutch application and slip. There's also the danger of the pump taking in air and causing foaming. This in turn causes mushy application of clutches and bands, and excessive wear. It may even cause the fluid to break down—and this can happen in a low-mileage job—and cause sludge and varnish in the hydraulic system.

If there's too much fluid, it can be just as bad. The gear train can churn it up with the same results as the pump sucking air. So it's best to be sure the fluid level is correct **before** you make any other tests —to be sure the transmission won't act erratically.

Warmed Up

Be sure the fluid is warmed up and move the selector lever through all the ranges to fill the clutches and servo. Then, with the engine still operating, check the level in the park position. It should be to the FULL mark on the dipstick, but **never higher.** If there's too much fluid, take some out. If it's low, add some.

Use Approved Fluids

Use only approved fluids that meet Ford specification M-2C33-D—either with the Rotunda label or with a Ford qualification number on the container (Fig. 84).

Fig. 84—Approved Fluid

An inferior fluid may break down and varnish the transmission. Approved fluid should last the lifetime of the car in normal driving conditions.

CHECK THE FLUID CONDITION

There are certain fluid conditions to watch for that will tell you an overhaul is necessary and further testing is useless. These are varnish on the dipstick or black fluid with the odor of a burned electrical coil and friction material in the fluid. If the fluid is varnished, the control valves are too—likewise the clutches and gears. Burned, black fluid means overheating and a clutch or band burned out. Further testing in either case is useless. You won't get any reliable indications because of stuck valves and plugged passages.

Of course, after any overhaul, be sure to perform the complete testing and adjustment procedure.

ENGINE IDLE

Incorrect engine idle can cause rough initial engagement in the transmission. When the idle is too high, you can have a throttle pressure input at closed throttle, and therefore too much control pressure applying the clutches. Set the engine idle as specified on the diagnosis guide.

THROTTLE (KICKDOWN) LINKAGE

Adjusting the throttle linkage is important to be certain the throttle and kickdown systems are properly adjusted. The kickdown system should come in when the accelerator is pressed through detent, and not before detent.

Ford Throttle Linkage Adjustment

1. Disconnect the throttle return springs (Fig. 85).
2. Loosen the conduit clamp on the carburetor control cable.
3. Push the accelerator pedal all the way to the floor and secure it.
4. Pull on the cable conduit until the throttle shaft lever is right against the wide-open stop. Tighten the clamp in this position.
5. Push down on the downshift rod until the lever on the transmission is against its internal stop. Hold the rod down and turn the downshift lever adjusting screw to take up **all** the clearance at the carburetor throttle shaft lever.
6. Lock the adjusting screw and release the accelerator pedal. Then connect the return springs.

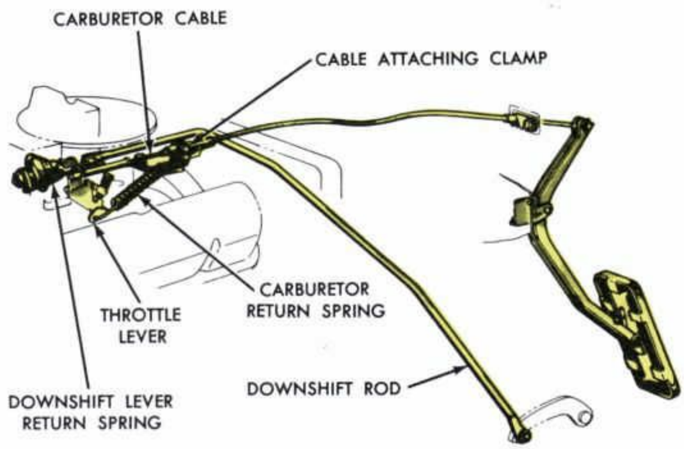


Fig. 85—Ford Throttle Linkage

Fairlane Throttle Linkage Adjustment

1. Disconnect the carburetor rod and the accelerator rod (Fig. 86).
2. Disconnect the stabilizer rod from the bell crank lever.
3. Insert a 1/4-inch diameter pin through the bell crank and bracket.
4. Adjust the length of the stabilizer rod so that the trunnion enters the bell crank freely, with the alignment pin in place. Secure the stabilizer rod with the retaining clip.
5. Secure the carburetor rod to the bell crank with the attaching clip.
6. Adjust the length of the accelerator rod to obtain an accelerator pedal height of 4-4 1/4 inches measured at the pedal as shown. Connect the accelerator rod to the accelerator shaft with the retaining clip after the proper accelerator pedal height has been established. Remove the alignment pin.

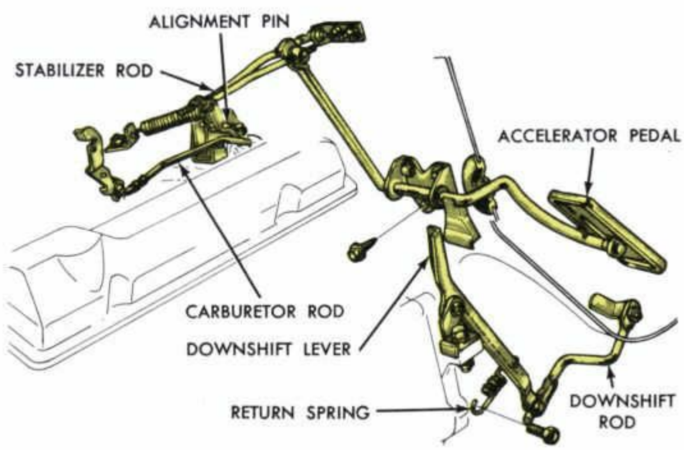


Fig. 86—Fairlane Throttle Linkage

7. With the engine off, disconnect the downshift rod trunnion from the lever.
8. With the carburetor choke in the **off** position, depress the accelerator pedal to the floor. Block the pedal to hold it in the wide-open position.
9. Rotate the downshift lever on the transmission in a counterclockwise direction to place it against the internal stop.
10. Adjust the trunnion so that it enters the downshift lever freely.
11. Turn the trunnion one additional turn counterclockwise to lengthen the rod. Secure it to the lever with the retaining clip.
12. Release the accelerator pedal.

Thunderbird Throttle Linkage Adjustment

1. Be certain the idle is correct in D1 or D2 and that the carburetor throttle lever is against the idle adjusting screw.
2. If the carburetor has an anti-stall dashpot, adjust the clearance. With the anti-stall dashpot plunger bottomed, the clearance with the throttle lever must be 0.060 to 0.090 inch.
3. Check that the fast idle cam is on the **hot** position.
4. Adjust the accelerator pedal height to specification at the carburetor connecting link (Fig. 87).
5. Position the speed nut on the downshift lever rod $1\frac{1}{4}$ inches from the forward face of the bushing in the downshift lever.

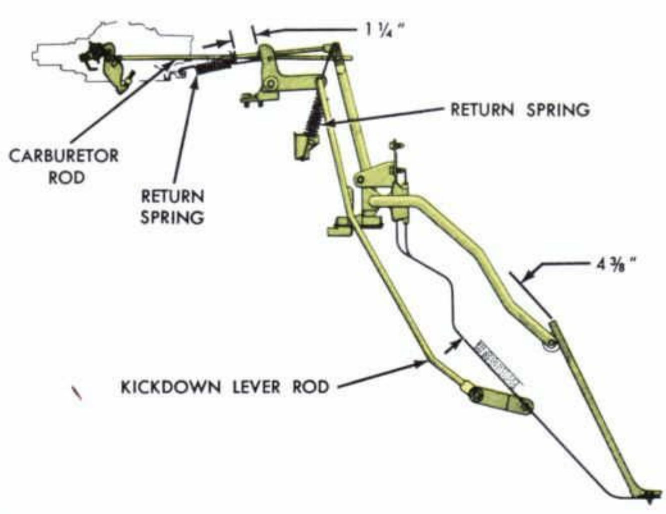


Fig. 87—Thunderbird Throttle Linkage

MANUAL VALVE LINKAGE

The manual valve linkage also can cause erratic operation if it's misadjusted. You can usually check the adjustment without disconnecting anything. Remember that the manual valve is located by a spring-loaded, V-shaped plunger, which pockets into notches in the manual valve. If the detents are synchronized with the selector positions, everything is okay.

Checking Linkage Adjustment

1. Move the selector lever from neutral to D1 and back into D2. There are no gate-type stops between neutral and D1, so you should feel the D2 detent when the pointer is right on the dot.
2. If you can feel the detent at the correct position, check that you can shift into all the other ranges to be sure the adjustment isn't off a full notch.
3. If the detent doesn't correspond with the dot, or if you can't shift into one of the extreme ranges (P or L), make the linkage adjustment.

Adjusting Manual Valve Linkage—Column Shift

1. Move the selector to D1.
2. Loosen the nut on the shift rod trunnion (Fig. 88) to permit the column shift lever to slide on the rod.
3. Shift the manual lever on the transmission to D1 (Fig. 89).

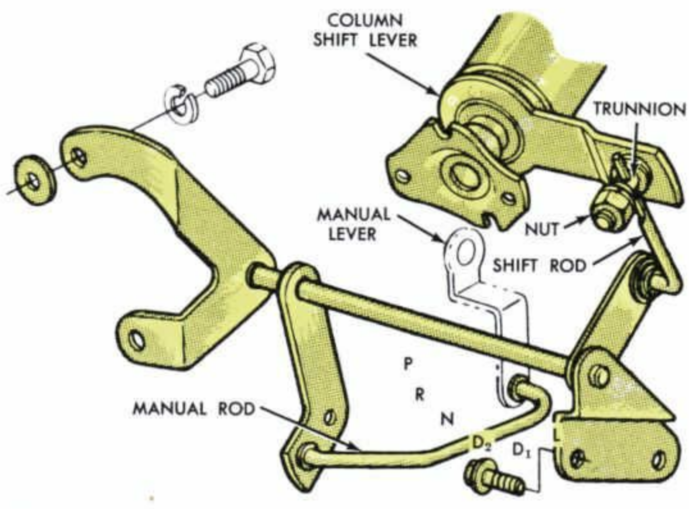


Fig. 88—Shift Linkage—Column Shift

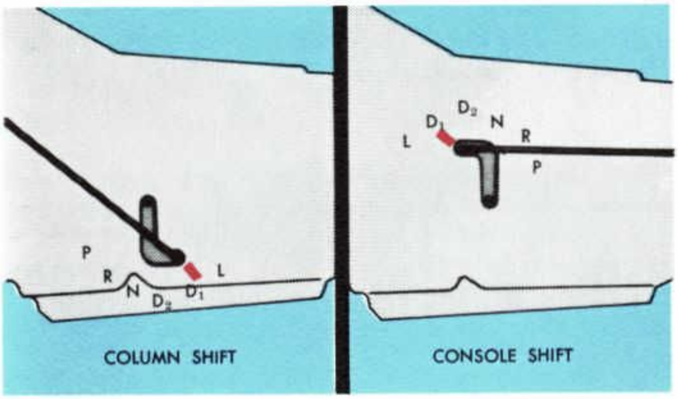


Fig. 89—Transmission Manual Valve Lever Positions

4. Check that the selector lever is against the gate stop in D1, then tighten the nut on the trunnion to the specified torque.
5. Check the other positions and for starting in park and neutral. If necessary, adjust the neutral start switch.

Adjusting Manual Valve Linkage—Console Shift

1. Move the selector to D1.
2. Loosen the nut (Fig. 90) that holds the manual lever control rod to the shift lever link.

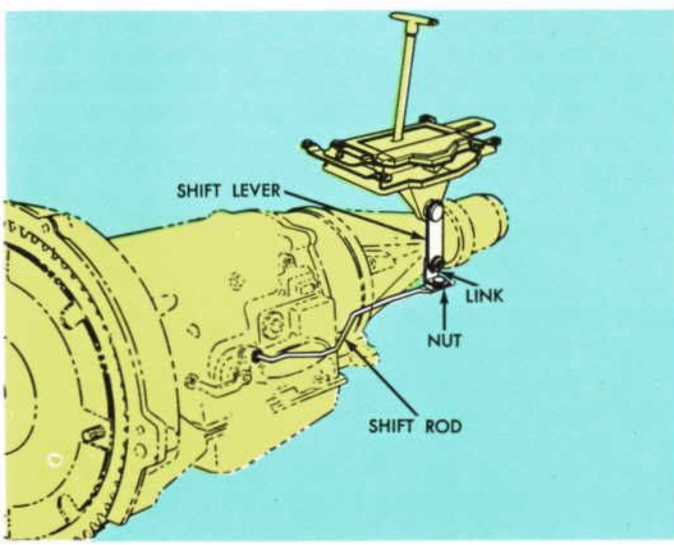


Fig. 90—Shift Linkage—Console Shift

3. Move the manual-shift lever on the transmission to the D1 position (Fig. 89).
4. Tighten the nut to the specified torque while the selector and shift lever are both in D1.
5. Check the other selector positions, and for starting in neutral and park. If necessary, adjust the neutral start switch.

NEUTRAL START SWITCH ADJUSTMENT

The neutral start switch is adjusted at the factory to prevent the engine from cranking in any range except neutral and park. It seldom requires field adjustment, but if the adjustment is off, there is danger of an accident occurring if the driver inadvertently cranks the engine in a driving range.

If the switch requires adjustment:

1. Loosen the switch retaining bolts (Fig. 91).

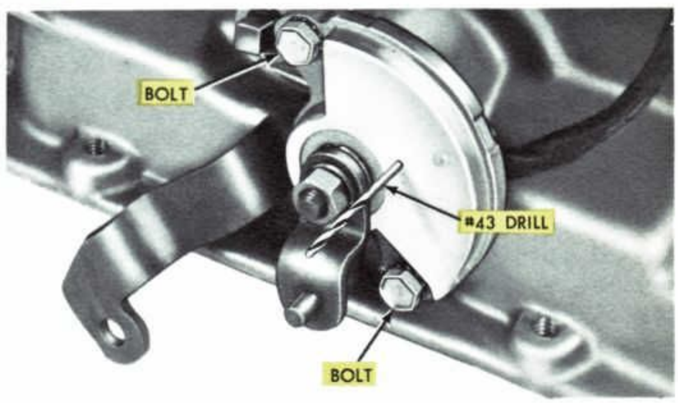


Fig. 91—Neutral Start Switch

2. Align the gauge pin holes and insert a No. 43 drill or gauge pin of equal size through all **three** holes.
3. With the gauge pin in place, tighten the bolts to the specified torque.
4. Check the adjustment by cranking the engine in neutral and park.

STALL TEST

The stall test is used to check for clutch slippage in the transmission, torque converter operation and engine performance. Quite simply, the stall test consists of checking the maximum engine rpm at stall in D2, D1, manual low and reverse.

NORMAL OPERATING TEMPERATURE

Never make a stall test without first checking that the engine coolant level and transmission fluid level are correct. Then be sure the engine is up to operating temperature. If necessary, operate it in neutral at 1200 rpm until the temperature is up.

STALL TEST PROCEDURE

1. Connect the tachometer and position is so you can read it from the driver's seat. Mark the maximum specified rpm on the dial window with a grease pencil.
2. Apply the parking brake and service brakes firmly.
3. Shift the selector lever to the range being tested.
4. Push the accelerator pedal steadily to the floor and hold it there just long enough for the tachometer reading to stabilize. Five seconds should be enough.
5. Record the engine rpm on the diagnosis guide.
6. Return the selector lever to neutral and operate the engine at 1000 rpm for at least a minute for cooling.
7. Repeat the above procedure in each driving range.

HIGH RPM MEANS SLIP

If at any time the rpm exceeds the maximum specified, a clutch is slipping in the transmission. Get off the gas quickly so you don't cause any more damage.

Of course, with the rear wheels stationary, the transmission can't upshift during the stall test. So if you keep in mind what's applied, starting in each range, you can usually figure out where the slipping is.

RANGE	HOLDING MEMBERS APPLIED	
D2	Forward Clutch	—Band
D1	Forward Clutch	—One-Way Clutch
L	Forward Clutch	—Low-and-Reverse Clutch
R	Reverse-and-High-Clutch	— Low-and-Reverse Clutch

Here are some of the possibilities:

- Slip in all ranges—Control pressure lost
- Slip in D2, D1 and L—Forward Clutch
- Slip in D1 only—One-way Clutch
- Slip in reverse only—Reverse-and-High Clutch or Low-and-Reverse Clutch

Sometimes you'll have to go on to the road test to tell where the slip is or if there is slip. The low-and-reverse clutch can slip in reverse, but you won't know if it slips in L range because the one-way clutch holds. If the intermediate band slips in a D2 stall test, the one-way clutch will take over—again, you will have to test on the road.

RPM TO SPECIFICATIONS

It's just as important to note now that if you have a good stall test in any range or ranges, the holding members in that range are okay. The only exception to this rule is the band. If it doesn't apply in D2, the one-way clutch can hold and you won't get any slip. The band must be checked during the road test.

Another important point is that a good stall test rpm in **any** range means the engine performance is okay and the converter stator clutch is doing its job.

LOW RPM ON STALL TEST

Low stall speed indicates either that the engine is sick or that the converter stator one-way clutch isn't holding. You can find out quickly which it is by driving the car.

If the clutch doesn't lock the stator, you'll have poor acceleration up to about 30 mph. But above 30 mph, acceleration will be normal. With a sick engine, you'll probably have poor performance at all speeds.

One other thing to keep in mind is this—if the one-way clutch is seized and locks the stator from turning either way, you'll have normal rpm on the stall test, but you'll have a 2:1 reduction in the converter all the time and won't be able to go faster than about 50 mph. If this ever happens, take a hard look at the transmission fluid, because a lot of heat is generated when the converter stays in reduction all the time.

ROAD TEST

A properly conducted road test is really your most valuable diagnosis tool if you know your transmission and apply this knowledge.

The front of the diagnosis guide lists the road speed specifications for each upshift and downshift and has spaces to record the actual shift points. Here's how you go about checking them, and what you should be thinking about during each check.

Before you go on the road, install an extra return spring on the downshift rod so you'll be sure to be able to "feel" the detent.

MINIMUM THROTTLE SHIFTS

To check the minimum throttle upshifts, give it just enough gas to barely accelerate the car. The diagnosis guide specifies above 17 inches of vacuum for all minimum throttle shifts (Fig. 92). That means throttle pressure should be less than 10 psi—not enough to raise control pressure or to cause modulated throttle pressure to act on the shift valves to delay upshifts.

When you move the selector to D1, the forward clutch and governor supply system is charged with control pressure. The clutch applies, and with the one-way clutch holding, you are in first gear. Control pressure to the governor is dead-ended between the lands of the primary governor valve so that the secondary valve is held in and there is no governor pressure.

Throttle Opening	Range	Shift	Engine Axle 390-2V, 4V 3.00:1 428-4V 3.00:1		Engine Axle 390-2V, 4V 3.25:1 428-4V 3.25:1		Engine Axle 390-4V 2.80:1 428-4V 2.80:1	
			Spec.	Record Actual	Spec.	Record Actual	Spec.	Record Actual
Closed (Above 17" Vacuum)	D^1	1–2	7–14		6–12		8–14	
	D^1	2–3	11–22		11–20		13–23	
	D^2	3–2	7–9		6–8		8–10	
	D^1	3–1	7–9		6–9		8–10	
	L	2–1	7–9		6–8		8–10	
To Detent (Torque Demand)	D^1	1–2	28–43		26–39		32–47	
	D^1 D^2	2–3	52–74		48–67		59–80	
	D^1 D^2	3–2	21–40		20–36		24–43	
Through Detent (W.O.T.)	D^1	1–2	38–46		35–42		43–50	
	D^1 D^2	2–3	72–84		66–76		81–90	
	D^1 D^2	3–2	64–75		59–68		73–81	
	D^1	2–1 or 3–1	26–34		24–31		30–37	

Fig. 92—Minimum Throttle Shift Points

As you drive off in first gear, you can be fairly sure the primary governor valve is not stuck in the out position. If it was, the connecting passage between the valves would be vented and governor pressure would build up immediately, causing an immediate upshift to second.

Minimum Throttle 1-2

When you reach about 10 mph, governor pressure cuts in. Since there's no modulated throttle pressure, the 1-2 shift valve train moves to charge the servo apply system. The servo is applied with the 1-2 accumulator valve and 1-2 scheduling valve cushioning the application. A smooth 1-2 shift at 10 mph tells you the governor, 1-2 shift valve train, accumulator and scheduling valve are all free and that the servo is applying the band. If the band doesn't apply, you'll stay in first gear and upshift to third at a higher speed.

Minimum Throttle 2-3

Without increasing the throttle setting, check for the 2-3 upshift around 15 mph. (In all cases, the exact ranges specified for each engine-axle-tire combination are listed on the guide.) Now, governor pressure has risen high enough to overcome the 2-3 shift valve spring. (There is still no modulated throttle pressure.) The 2-3 shift valve moves and charges the reverse-and-high clutch system. The clutch applies and at the same time release pressure on the servo releases the band. The governor is still doing its job, the clutch circuit is hydraulically tight, and the 2-3 shift valve is free.

Closed Throttle 3-2

In D2 range, let the car coast down in high gear. As the governor pressure cuts out at 10 mph, the 2-3 shift valve is forced back by its spring, and relieves pressure in the reverse-and-high clutch system. The clutch comes off immediately and servo release pressure is exhausted through an orifice to cushion the 3-2 downshift because the 3-2 coasting control valve is bottomed in its bore by spring force. A smooth downshift tells you the 3-2 coasting control valve is free and both governor valves are still working properly.

Closed Throttle 3-1

In D1 range, also check the coastdown shift. When governor pressure cuts out, both the 2-3 shift valve and the 1-2 shift valve train move up from spring force. Only the forward clutch is still pressurized and the car is freewheeling.

Closed Throttle 2-1

When you shift out of high gear in D1 or D2 to manual low (L) range, the transmission downshifts to second. If you start at a high enough road speed (55 mph) and don't get slip on this shift, the coasting boost valve is free.

Then, when governor pressure cuts out as you coast down to 10 mph, you get a 2-1 downshift. This time, though, first gear is not freewheeling, since the low-and-reverse clutch is on. To be sure the low-and-reverse clutch is holding, accelerate to 25 mph in first gear (L) and then test for engine braking.

"TO DETENT" SHIFTS

The "to detent" upshifts (Fig. 93) are full-throttle shifts. Throttle pressure is maximum and boosted throttle pressure acts on the modulator valve so maximum modulated throttle pressure is available to delay the upshifts. There is no downshift valve input to the shift valves.

Throttle Opening	Range	Shift	Engine Axle 390-2V, 4V 3.00:1 428-4V 3.00:1		Engine Axle 390-2V, 4V 3.25:1 428-4V 3.25:1		Engine Axle 390-4V 2.80:1 428-4V 2.80:1	
			Spec.	Record Actual	Spec.	Record Actual	Spec.	Record Actual
Closed (Above 17" Vacuum)	D^1	1–2	7–14		6–12		8–14	
	D^1	2–3	11–22		11–20		13–23	
	D^2	3–2	7– 9		6– 8		8–10	
	D^1	3–1	7– 9		6– 9		8–10	
	L	2–1	7– 9		6– 8		8–10	
To Detent (Torque Demand)	D^1	1–2	28–43		26–39		32–47	
	D^1 D^2	2–3	52–74		48–67		59–80	
	D^1 D^2	3–2	21–40		20–36		24–43	
Through Detent (W.O.T.)	D^1	1–2	38–46		35–42		43–50	
	D^1 D^2	2–3	72–84		66–76		81–90	
	D^1 D^2	3–2	64–75		59–68		73–81	
	D^1	2–1 or 3–1	26–34		24–31		30–37	

Fig. 93—"To Detent" Shift Points

To Detent 1-2 and 2-3

In D1 range, push the accelerator to the detent and hold it there. Check the upshift points. If they're to specifications, the throttle valve, throttle booster valve and throttle modulator valve are operating freely. Also, the governor still is doing a good job.

To Detent 3-2

At about 25 mph in high gear, push the accelerator to the detent. This brings in boosted throttle pressure which raises modulated throttle pressure enough to force the 3-2 shift. Governor pressure at this speed is holding the 3-2 coasting control valve shifted against its spring if the valve is free. Therefore, the servo release pressure exhausts directly instead of through the orifice and the shift occurs quickly. Going into low gear momentarily on this shift could mean a stuck 3-2 coasting control valve is delaying the band application.

Throttle Opening	Range	Shift	Engine Axle 390-2V, 4V 3.00:1 428-4V 3.00:1		Engine Axle 390-2V, 4V 3.25:1 428-4V 3.25:1		Engine Axle 390-4V 2.80:1 428-4V 2.80:1	
			Spec.	Record Actual	Spec.	Record Actual	Spec.	Record Actual
Closed (Above 17" Vacuum)	D^1	1–2	7–14		6–12		8–14	
	D^1	2–3	11–22		11–20		13–23	
	D^2	3–2	7– 9		6– 8		8–10	
	D^1	3–1	7– 9		6– 9		8–10	
	L	2–1	7– 9		6– 8		8–10	
To Detent (Torque Demand)	D^1	1–2	28–43		26–39		32–47	
	D^1 D^2	2–3	52–74		48–67		59–80	
	D^1 D^2	3–2	21–40		20–36		24–43	
Through Detent (W.O.T.)	D^1	1–2	38–46		35–42		43–50	
	D^1 D^2	2–3	72–84		66–76		81–90	
	D^1 D^2	3–2	64–75		59–68		73–81	
	D^1	2–1 or 3–1	26–34		24–31		30–37	

Fig. 94—"Through Detent" Shift Points

"THROUGH DETENT" SHIFTS

Through the detent, we have the downshift system charged, exerting the maximum shift-delay force on the shift valves. The shifts will come in at the highest shift points (Fig. 94). In D1 range, we can kick down to low gear only by going through the detent. Check the through detent-upshifts by pushing the accelerator to the floor in D1 and holding it there. Check the kickdown shift points by pushing the accelerator through the detent at the appropriate road speed. These shift points are a check on the downshift valve and on governor pressure output above 10 mph.

SHIFT QUALITY

Of course, while you're driving the car, you'll want to pay attention to the "feel" of the shifts as well as the speed they occur at. Harsh or mushy shifts can point to incorrect throttle pressure, or to individual valves, depending on whether just certain shifts are involved or the problem is general.

OPERATING CONDITIONS

On the back of the diagnosis guide, you have a table labeled "Operating Conditions." Most of the possible troubles on the road test are listed here, and you should mark those you encounter for diagnosis purposes.

BAND ADJUSTMENT

If you have any difficulty with intermediate gear on the road test, a band adjustment is in order when you get back.

Some possible indications of a slipping band are:

- First gear start in D2
- Upshift directly from first to high
- Bump on 1-2 upshift or dragged-out shift

Besides adjusting the band, look for any evidence of leakage around the servo cover seal.

ADJUSTING PROCEDURE

1. Loosen the locknut on the adjusting screw several turns (Fig. 95).
2. Torque the screw to 10 ft-lbs, or until the adjuster wrench overruns.
3. Back the screw off exactly one turn.
4. Hold the adjustment and torque the locknut to the 35-45 ft-lbs.

Of course, if second gear appeared to be your only problem, you should repeat those parts of the road test.

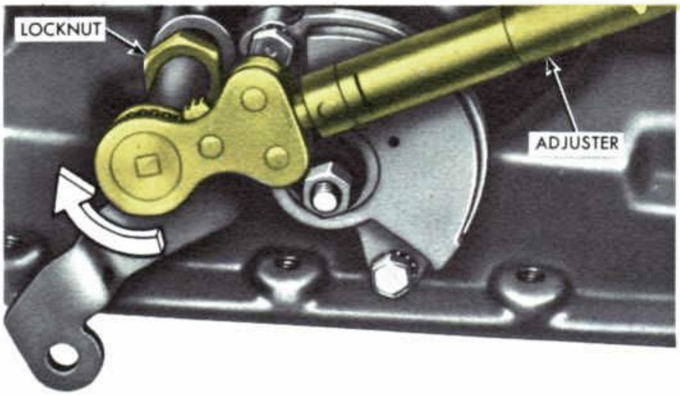


Fig. 95—Band Adjustment

CONTROL PRESSURE TESTING

Pressure tests should be performed anytime there is slip in the gear train or the shift feel isn't right. Harsh, delayed upshifts often are the result of too much throttle pressure. The harshness comes from the throttle boost to control pressure and the delay from excess modulated throttle pressure. Of course, slip and no-drive conditions can be caused by too little control pressure—either from excess leakage in the system or sticking valves.

If you come back from the road test with a slipping hydraulic clutch, the control pressure test in the various ranges will probably tell you whether the slip is caused by a hydraulic leak or mechanical failure.

In the pressure tests, we begin by checking control pressure in all the ranges with no throttle pressure input, then we check the control pressure rise when we pull the vacuum down and build throttle pressure.

PRESSURE CHECK AT IDLE

1. With the vacuum gauge and pressure gauge connected (Fig. 82 and Fig. 83), place the tester where you can read the gauges from the driver's seat.
2. Check that the manifold vacuum is high—at least 18 inches. If the vacuum is very low, crack the throttle a little and it should rise. If it doesn't, locate and correct the leak before you go on.

At higher altitude than sea level, you may not be able to get the vacuum as high as 18 inches. In that case, these are your control pressure specifications for idle operation:

Engine Vacuum at Idle	Control Pressure (psi)
17″	51-66
16″	51-72
15″	51-78
14″	51-84
13″	51-90
12″	51-97
11″	51-103

3. Depress and release the accelerator quickly to be sure that vacuum changes with throttle setting. If the vacuum changes seem to lag, you may have a restricted vacuum line to the diaphragm. Repair it before you go on.
4. Record the control pressure in all ranges on your diagnosis guide (Fig. 96).

Engine R.P.M.	Manifold Vacuum Ins. Hg.	Throttle	Range	P.S.I. Control Pressure Spec.	P.S.I. Control Pressure Rec. Act.	P.S.I. Throttle Pressure Spec.	P.S.I. Throttle Pressure Rec. Act.
Idle	Above 17	Closed	P	51–66		0–13	
			N	51–66		0–13	
			D^1	51–66		0–13	
			D^2	51–66		0–13	
			L	51–66		0–13	
			R	72–108		0–13	
As Req'd.	15	As Req'd.	D^1	70–78		20–22	
As Req'd.	10	As Req'd.	D^1	98–109		40–44	
As Req'd.	1 or Lower	Open	D^1	157–172		77–84	
			D^2	157–172		77–84	
			L	157–172		77–84	
			R	230–252		77–84	

Fig. 96—Control Pressure Specifications

Low Pressure at Idle

Low pressure in all the ranges at idle points to some problem in the pressure supply—low pump output; excessive leakage in the pump, case or valve body; or a sticking regulator valve.

If the pressure is low in only certain ranges, there is probably a hydraulic leak in one of the systems that's charged in those ranges. For example, a leak in the forward clutch and governor system could cause low pressure in all forward ranges but pressure would be good in reverse, park and neutral. Of course, the leak would have to be bad enough that the pump volume could not keep up with the leakage.

High Pressure at Idle

High pressure at idle probably is caused by a throttle pressure input to the pressure booster valve. If the diaphragm leaks, for instance, throttle pressure is going to be high and will boost control pressure.

To check where the vacuum leak is, remove the vacuum gauge tee and connect the gauge directly to the vacuum hose to see if vacuum is higher with the diaphragm out of the picture. If necessary, check vacuum at the other end of the hose to see if the hose leaks. Of course, if either the hose or diaphragm unit leaks, it must be replaced.

PRESSURE RISE CHECK

1. Set the parking brake and apply the service brakes firmly.
2. In the forward ranges, increase the throttle setting to pull the vacuum down to 15 inches and record the control pressure. Repeat the procedure and record the pressures at 10 inches of vacuum and at less than one inch. Make the final test in reverse also.
3. Between tests, operate the engine at 1000 rpm in neutral for a minute for cooling.

Pressure Doesn't Increase

If you don't get a pressure increase as vacuum drops, check the mechanical connection between the diaphragm and throttle valve. If the control rod isn't assembled, there's no spring force on the throttle valve so throttle pressure can't build up.

Pressure Increases not to Specifications

If the pressure does increase, but is not within specifications, you may have a stuck throttle valve, pressure booster valve or regulator valve. You can isolate the cause by actually reading throttle pressure on the C6 transmission.

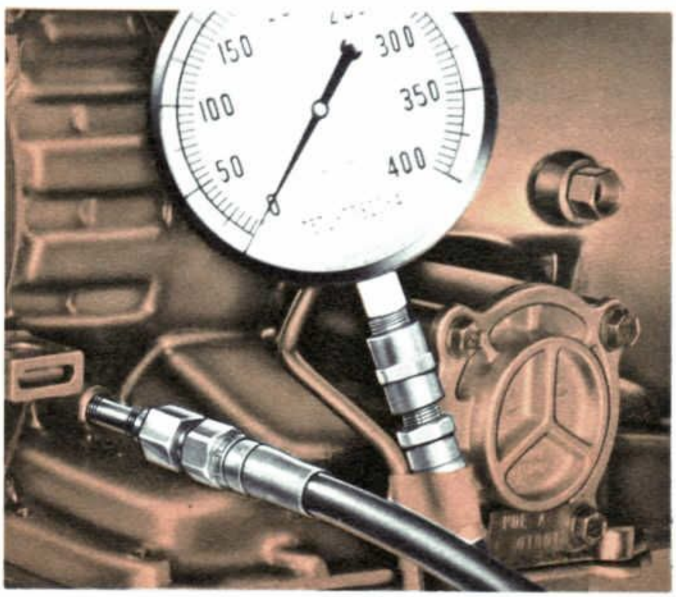


Fig. 97—Throttle Pressure Gauge Connection

Throttle Pressure Gauge

Connect another pressure gauge to the throttle pressure tap (Fig. 97). Check the throttle pressure against these specifications:

Engine Speed	Throttle	Manifold Vac. (Ins. Hg.)	Range	Throttle Pressure (psi)	Control Pressure (psi)
Idle	Closed	Above 17"	P, N, D1, D2, L & R	0-13 0-13	51-66 72-108
As Req'd	As Req'd	15"	D1, D2, L	20-22	70-78
As Req'd	As Req'd	10"	D1, D2, L	40-44	98-109
As Req'd	Open	0.5"	D1, D2, L R	77-84 77-84	157-172 230-252

If throttle pressure is okay and control pressure isn't, your trouble is in the valve body. If throttle pressure is low, the throttle valve is at fault.

Adjusting the Diaphragm

On rare occasions, the diaphragm assembly may need adjusting. It's preset at the factory, but once in awhile all the pressure readings are slightly high or low and adjusting the spring tension will fix it.

The adjusting screw is accessible by removing the vacuum line (Fig. 98). One full turn of the screw changes the control pressure two to three psi. Turn the screw in to increase pressure; out to decrease it.

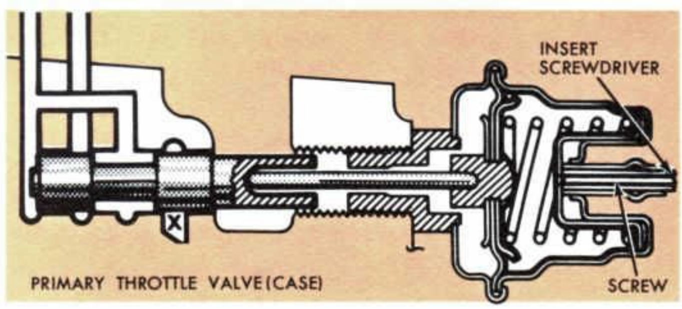


Fig. 98—Diaphragm Adjusting Screw

Important: Never adjust the pressure below specifications to alter the shift feel. That's asking for slip and burned clutches.

ALTITUDE-COMPENSATED DIAPHRAGM

The altitude-compensated diaphragm unit can be adjusted the same way. But pressure specifications for units equipped with the altitude-compensated diaphragm are different (Fig. 99). The barometric pressure must be taken into consideration when pressure testing these units. If a barometer or weather report is not available, use the specifications for the altitude where you're making the check. The exact barometric pressure, of course, is more reliable.

AT SEA LEVEL (BAROMETER 29.50)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
ABOVE 17 (IDLE)	P, N, D2, D1, L	51-66	0-13
	R	72-108	
15	D2, D1, L	70-78	20-22
10	D2, D1, L	98-109	40-44
1 OR LOWER	D2, D1, L	157-172	80-84
	R	230-252	

1000 FEET (BAROMETER 28.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0-11
	R	72-104	
15	D2, D1, L	67-75	18-20
10	D2, D1, L	94-105	38-41
1 OR LOWER	D2, D1, L	149-163	77-81
	R	220- 242	

2000 FEET (BAROMETER 27.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0-8
	R	72-99	
15	D2, D1, L	63-71	15-17
10	D2, D1, L	91-101	36-38
1 OR LOWER	D2, D1, L	145-159	74-78
	R	215-236	

3000 FEET (BAROMETER 26.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0-5
	R	72-96	
15	D2, D1, L	59-67	12-14
10	D2, D1, L	87-97	33-36
1 OR LOWER	D2, D1, L	142-157	72-76
	R	211-231	

4000 FEET (BAROMETER 25.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0-3
	R	72-92	
15	D2, D1, L	57-64	10-12
10	D2, D1, L	85-94	31-33
1 OR LOWER	D2, D1, L	139-154	70-74
	R	207-227	

5000 FEET (BAROMETER 24.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0
	R	72-83	
15	D2, D1, L	51-60	7-9
10	D2, D1, L	81-90	28-31
1 OR LOWER	D2, D1, L	136-151	67-72
	R	202-222	

6000 FEET (BAROMETER 23.5)

VACUUM GAUGE (INCHES)	SELECTOR POSITION	CONTROL PRESSURE (PSI)	THROTTLE PRESSURE (PSI)
IDLE	P, N, D2, D1, L	51-59	0
	R	72-83	
15	D2, D1, L	51-60	5-7
10	D2, D1, L	78-87	26-28
1 OR LOWER	D2, D1, L	132-147	64-68
	R	198-217	

Fig. 99—Pressure Specifications—Altitude Compensated Diaphragm

PERFORMANCE CHART

After you've completed the pressure tests (and necessary adjustments and repairs), turn to the back page of your diagnosis guide. Check off whether control pressure is correct and whether all the control valves are functioning. Drive the car again, if necessary, to find out whether your adjustments have corrected the trouble.

If there are still troubles after the procedure is completed, consult the letter codes for possible causes. The codes are in the order of likeliest causes. Mark off the checks you have already performed and check what's left in the proper order.

AIR PRESSURE TESTS

When you have a slip problem but don't know whether it's in the valve body or in the hydraulic system beyond the valve body, the air pressure tests can be very valuable.

Blowing air in the various pressure passages (Fig. 100), you will tell if the clutch and servo circuits are hydraulically tight. For example, if you had slip in all forward gear ranges, you suspect the forward clutch is slipping. If the trouble is a seal leak inside the transmission, you probably can't apply the clutch with air. But if you get a distinct thud or can feel the piston applying with your hand, the hydraulic system is tight. Unless the clutch is burned out (which you should know by now from friction material in the oil), the trouble must be somewhere else.

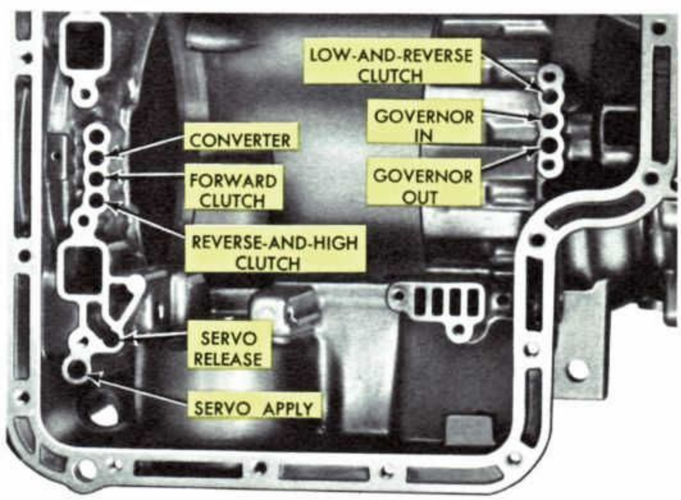


Fig. 100—Pressure Passages

FORWARD CLUTCH

Apply air pressure to the transmission case forward clutch passage. A dull thud can be heard when the clutch piston is applied. If no noise is heard, place your finger tips on the input shell and again apply air pressure to the forward clutch passage. Movement of the piston can be felt as the clutch is applied.

INTERMEDIATE SERVO

Hold the air nozzle in the intermediate servo apply passage. Operation of the servo is indicated by a tightening of the intermediate band around the drum. Continue to apply air pressure to the intermediate servo apply passage, and introduce air pressure into the intermediate servo release passage. The intermediate servo should release the band against the apply pressure.

GOVERNOR

Apply air pressure to the governor out passage and listen for a noise similar to a model airplane engine revving at high speed. The noise tells you the valve is free—it is "hunting" with a high volume of air supplied.

LOW-AND-REVERSE CLUTCH

Apply air pressure to the clutch apply passage. A dull thud indicates the clutch piston has applied.

REVERSE-AND-HIGH CLUTCH

Apply air pressure to the reverse-and-high clutch passage. A dull thud indicates that the reverse-and-high clutch piston has moved to the applied position. If no noise is heard, place the finger tips on the clutch drum and again apply air pressure to detect movement of the piston.

DEFINITIONS

Accelerate—to increase speed as opposed to maintaining a steady speed.

Atmospheric Pressure—pressure on all objects in the atmosphere due to the weight of the atmosphere's air. About 15 psi absolute or 29.92 inches of mercury absolute at sea level.

Balanced Valve—a regulating valve which controls a pressure of just the right value to balance other forces acting on the valve.

Centrifugal Force—force on a revolving object that tends to push it away from the center of revolution. Centrifugal force increases with the square of the speed of rotation.

Differential Areas—two surfaces on a control valve with different surface areas exposed to pressure. The same pressure working on differential areas causes an unbalanced force.

Energy—the capacity to do work.

Force—a push or pull. Measured in units of weight —usually pounds.

Hunting—a condition where a hydraulic valve oscillates on either side of its balanced position because of small changes in the balancing forces.

Journal—a bearing or seal surface on a rotating shaft.

Kickdown—forcing a downshift by overriding the transmission's automatic selection of the best gear ratio for the prevailing engine load and road speed conditions.

Land—the large diameter part of a sliding valve that is fitted to the valve bore.

One-Way Clutch—an overrunning clutch that locks up in one direction of rotation and overruns or freewheels in the other.

Orifice—a restricted opening in a line or passage used to delay the application of pressure downstream or to create a pressure difference when fluid is flowing through the orifice.

Overrunning Clutch—see one-way clutch.

Pressure—force per unit area measured in pounds-per-square inch or psi.

Reduction — "gearing down." Increasing output torque by driving the output member at a slower speed than the input.

Stall—a condition where the engine is operating and the transmission is in gear, but the rear wheels are not turning. The converter turbine is standing still.

Sump—the fluid reservoir or storehouse. In an automatic transmission, the oil pan. The sump is always vented to atmospheric pressure.

Torque—a twisting or turning force.

Torque Converter—an automatic fluid clutch that also "gears down" or multiplies engine torque.

Torque Demand Downshift—a power-on downshift which comes in automatically. The demand comes from throttle pressure produced by a steadily applied accelerator pedal.

Torque Multiplication—mechanical advantage gained by "gearing down" or through the action of the vortex flow in the torque converter.

Vortex Flow—recirculating flow between the converter impeller and turbine that causes torque multiplication.

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