HOW THE HYdraulically OPERATED TRANSMISSION OPERATES

IT'S EASY ONCE YOU KNOW HOW!
The more you learn about the hydraulically operated transmission, the more you'll realize how simple it really is.

Like any transmission, the hydraulically operated transmission is placed in the car to give the driver his choice of gear ratios, so that he can make the wheels turn rapidly with moderate power for cruising; or make the wheels turn slowly with lots of power for acceleration and pulling. The big advantage of the hydraulically operated transmission is its ease of operation. Most of the time the driver doesn't have to use the clutch or gearshift lever. He controls the shift by means of the accelerator pedal.

Besides being easy on the driver, the hydraulically operated transmission is also easy on the man who's doing trouble-shooting when something goes wrong. Using a test light, you can diagnose about 90% of all difficulties in a very few minutes . . . that is, if you understand how the transmission works. So, first of all, let's get straight on the different speeds and ranges.
Four Speeds and Two Ranges

The hydraulically operated transmission is the constant-mesh type with four forward speeds. The gears are divided into two ranges—power and driving—with two speeds in each range. The two speeds in the power range are “first” and “second.” In the driving range the two speeds are “third” and “fourth.”

Driving Range For Normal Driving

Almost ninety-eight per cent of the time, the driver operates the car in the driving range. To start, he pushes in the clutch pedal and moves the gearshift lever down to “driving” position. When he starts out, the car is operating in “third” speed. At speeds above approximately thirteen miles per hour, the driver lifts his foot from the accelerator pedal for an instant. The transmission then automatically shifts up to “fourth” speed for cruising.

The driver doesn’t have to shift gears when he slows down for turns or a stop. The transmission does it automatically by shifting down to third when the car speed drops below about eleven miles per hour.
Now, there'll be times when the car is being driven in fourth gear, and the driver wants a sudden burst of speed—maybe to pass a car. Up to approximately thirty-five miles per hour, the driver will get a faster burst of speed if he shifts into third. To do that he pushes the accelerator pedal all the way down. When he wants to shift up to fourth speed again he lifts his foot from the accelerator, and the transmission upshifts automatically.

Power Range For Pulling

Power range is used only when the driver wants lots of power—when he's starting up on a grade, or when he's driving in extremely hilly country and needs to use the engine for braking. In the power range, the transmission is ready to shift up at about six miles per hour, and it automatically shifts down at about four miles per hour.
**How The Speeds Are Changed**

Since this is a constant-mesh transmission, the forward speed gears do not slide into or out of mesh when the speeds are changed. Actually, they always remain in the same position on the shafts. The speeds are selected by moving shift sleeves back and forth. These sleeves control the speeds by locking or coupling the gears to the shafts or to each other when necessary, and letting the gears “coast” when they’re not needed.

![Cartoon](image)

**Here’s a Map of the Transmission**

In order to explain how the sleeves control the speeds we’re going to duck down inside the transmission for a few moments and look at each of the sleeves in turn. So, to keep you on the trail, we’ve printed up this “map” of the transmission. It’ll show you where the different parts are and help you figure out how they do their job.

![Map](image)
The Manual Clutch Gear Sleeve

The shift between the driving range and the power range is handled by the manual clutch gear sleeve. It's controlled by linkage leading to the gearshift lever. This sleeve slides on the manual clutch gear, which is splined to the main shaft. When the manual clutch gear sleeve is back (toward the propeller shaft), it couples the first speed gear to the main shaft through the manual clutch gear. The transmission then operates in first speed or second speed in the power range. When the sleeve is forward, it couples the third speed gear to the main shaft. The transmission then operates in third speed or fourth speed in the driving range.

Direct Speed Clutch Sleeve

The direct speed clutch sleeve has the job of automatically shifting the transmission between first and second speeds in the power range, and between third and fourth in the driving range.

It works something like the manual clutch gear sleeve. It slides back and forth on the hub of the third speed gear. When it's back, the sleeve isn't doing anything. But, when it's moved forward, it couples the main drive pinion to the third speed gear.
**Constant Mesh Gear Control Sleeve**

When the direct speed clutch sleeve moves forward it carries with it another sleeve called the *constant mesh gear control sleeve*. This sleeve rides on the hub of the countershaft gear. The constant mesh gear control sleeve controls the position of the rollers in the constant mesh gear, making the gear either drive or “coast.”

**NOTE:**

How the constant mesh gear operates is included in the “Power Flow” story which you’ll find on pages 25 to 31. If the hydraulically operated transmission is new to you, the power flow story will help you get acquainted.

**A HEART-TO-HEART TALK ABOUT THE TRANSMISSION**

We’ve already said that the direct speed clutch sleeve handles the shift between first and second, and between third and fourth. Let’s go on now and see how the sleeve is moved forward to make the shift.

To begin with, the direct speed clutch sleeve is moved forward and back by an “arm” called a “shift fork.” It is the connecting link between the sleeve and the hydraulic system.
Now, just like the arm on a human body, the shift fork is operated by what we might call “muscles”—which are actually the direct speed piston, the rail, and a spring.

The direct speed piston is moved by hydraulic pressure from the oil pump, which is the “heart” of the transmission hydraulic system. The pump is the rotor-type, similar to the pump in the engine oiling system. The transmission oil pump is located in the transmission extension housing, and is driven from a pin in the main shaft.

**The Transmission's Got "Nerves"!!**

Yes, the “nerves” of the transmission are the electrical units that control the flow of oil to the direct speed piston. Take the solenoid, for instance. It operates the ball valve, which directs the flow of oil from the pump.

When current flows through the solenoid coil, a plunger on the lower end of the solenoid pushes the ball valve off its seat.
Oil from the pump then flows past the ball valve into the transmission sump, where it's recirculated by the pump. That means there's no pressure against the direct speed piston, so it stays back, keeping the shift fork back in the starting or "downshift" position.

But—when the circuit through the solenoid is broken, a spring called the "ball spring" pushes the ball and plunger up. That closes the opening to the sump, so that all the oil goes to the piston. The oil, under pressure from the pump, pushes the piston forward, compressing the piston return spring and fork engaging spring.

It's the pressure of the fork engaging spring that moves the fork, shift rail and direct speed clutch sleeve forward to complete the upshift.

When the ball valve opens again, the pressure against the piston is relieved, and the piston return spring forces the piston back to the starting or downshift position again.
**Pressure Stays Constant**

The hydraulic pressure in the system is automatically regulated by two oil relief holes located in the shift piston cylinder wall. As the piston moves ahead, it uncovers these two relief holes. The holes drain off enough oil to keep the pressure in the system constant at about forty pounds.

The "brain" of the transmission is an "automatic switch" called the governor. Its job is to make or break the circuit to the solenoid. The governor is the centrifugal type and is geared to the countershaft gear so that it turns faster or slower depending on the speed of the car and the gear you're driving in.
In the cover of the governor case there is a set of snap-action contact points which are controlled by governor weights. The points stay closed until the car reaches a speed of about thirteen miles per hour in the driving range, or about six miles per hour in the power range. Above these speeds, the weights fly out far enough to separate the points and break the circuit to the solenoid.

The governor is wired in the circuit so that when the points are closed, current flows from the hot wire on the coil through the circuit breaker (more about this later)... through the solenoid... through the governor points to ground.

THE UPSHIFT

Now we can understand what goes on inside the transmission when it upshifts.

When the car first starts out in the driving range, for example, the governor points are closed, because the car speed is less than thirteen miles per hour. Consequently, the solenoid plunger is pushed down, holding the ball valve down. Oil from the pump drains off to the sump in the transmission case. Since there's no pressure against the piston, it stays back and the transmission remains in third speed.
At speeds above approximately thirteen miles per hour, the governor points open, breaking the circuit through the solenoid. The ball spring pushes the ball and solenoid plunger up closing the discharge passage. With the ball valve closed, all the pressure from the pump is directed against the piston.

The piston moves forward, compressing the fork engaging spring and the piston return spring.

**LOADED AND READY!**

At this point, the fork engaging spring is “loaded,” ready to move the shift fork forward when the driver gives the signal. Then the driver lifts his foot from the accelerator pedal for an instant to slow down the engine. When he does, the speed of the main drive pinion matches the speed of the clutch sleeve. The fork engaging spring then pushes the sleeve forward onto the main drive pinion, completing the shift.

The shift from first up to second in the power range is made the same way, except that the piston moves forward at a car speed of about six miles per hour.
THE AUTOMATIC DOWNSHIFT

Whenever the driver slows down to below approximately eleven miles per hour in the driving range, the transmission automatically shifts down to third speed. In power range, the transmission shifts down from second to first gear at about four miles per hour. Here’s what happens.

The governor points close when the car speed drops below eleven miles per hour in the driving range, or about four miles per hour in the power range. When the points close completing the circuit, the solenoid is energized and the plunger pushes the ball valve off its seat. This opens the oil passage, dumps the oil and relieves pressure against the piston. The piston return spring tries to push the piston back, but it’s not strong enough to pull the clutch sleeve off the main drive pinion. That’s because driving pressure or torque is too great against the sleeve. So—
INTERRUPTER SWITCH
TO THE RESCUE!

The driving pressure against the clutch sleeve is relieved by a unit known as the “ignition interrupter switch.” It’s connected in the circuit between the ignition coil and the governor.

Mounted in the case directly above the piston, it’s made up of a disc, a pair of points, and a small steel ball that projects part way down into the piston bore. The piston itself is machined with a ridge with sloping sides on the front and a groove farther back. This shape makes it possible for the piston to act like a cam, controlling the ball.

When the piston starts to move back on the downshift, the ramp on the piston raises the ball and pushes the disc against the points, grounding the ignition circuit through the governor points for an instant.

The interrupter switch breaks the circuit just long enough to take the pressure off the clutch sleeve. Then the return spring pushes the piston back, pulling the clutch sleeve off the main drive pinion. When the piston has moved back, the ball drops down into its normal position. The switch contact is opened, and the ignition circuit is restored, so the engine doesn’t stall.

The interrupter switch does not break the circuit during an upshift, because the governor points are open then, and there’s no ground for the circuit.
KICKDOWN FOR EXTRA SPEED

Earlier we said there are times when the car is being driven in fourth gear, and the driver wants a sudden burst of speed. Up to about thirty-five miles an hour, he can get that burst of speed if he shifts down into third. And that's when he uses the kickdown switch.

The kickdown switch is located in the carburetor, and is operated by the accelerator pedal. Here's how it works:

The driver pushes the accelerator pedal all the way down. This closes the kickdown switch, establishing a ground to complete the circuit to the solenoid. The solenoid then opens the ball valve and dumps the oil so the transmission can downshift to third. Of course, the interrupter switch works the same as it did in the automatic downshift.
WHEN THE KICKDOWN SITS DOWN

The kickdown switch won’t operate at speeds above approximately thirty-five miles an hour.

You see, the switch contact is connected to a small piston which is controlled by suction in the carburetor throat. At speeds over about thirty-five miles an hour, that suction is strong enough to pull the piston, with its contact, up out of the way of the switch plunger that’s operated by the throttle linkage.

So, if the driver does push the accelerator pedal all the way down, the plunger moves in without touching the other contact. The circuit is not completed and the transmission is prevented from downshifting.
NO STALLING!

An anti-stall control is built into the carburetor to keep the throttle from closing too fast and stalling the engine when the driver lifts his foot off the accelerator pedal at slow speeds.

The anti-stall control contains a solenoid which is energized when the governor points are closed. When the anti-stall solenoid is energized it pulls a small steel ball onto a seat, blocking off the main exit port and forcing the fuel to flow through a smaller passage. This action keeps the fuel from being forced out of the dash-pot chamber too rapidly when the throttle is closed.
WATCHDOGS IN THE TRANSMISSION

The Circuit Breaker

The circuit breaker is a sort of "watchdog" that guards the transmission electrical system against damage from shorts or improper grounds. You'll find it mounted on the engine side of the left front fender, or on the front of the dash panel of some cars... on the air cleaner bracket of others.

The circuit breaker acts like an automatic fuse in the circuit between the coil and the solenoid. If the electrical system becomes overloaded because of a short or ground, the circuit breaker cuts off the current to prevent damage to the units or a heavy drain on the battery.
THE TWELVE-OHM RESISTOR

You'll find a twelve-ohm resistor connected in the interrupter switch circuit. It is located on the circuit breaker bracket. The purpose of the resistor is to prevent a feed-back of ignition system current from energizing the solenoid during an upshift.

You see, if the resistor wasn't used, or if anything should happen to it so it didn’t do its job, you’d have current flowing to the solenoid every time the distributor points closed. The result would be that the direct speed piston would “shuttle” back and forth instead of moving forward smoothly and positively to make the upshift.
Let’s suppose the resistor wasn’t there. Here’s what would happen. As the car speed increased above upshift speed, the governor points would open. This would break the circuit to the solenoid, so it would be de-energized. The spring would push the ball valve up against its seat, and the oil pressure would then go directly to the piston. But, as the piston moved forward it would close the contacts in the interrupter switch.

With the interrupter switch contacts closed, and the distributor points closed to establish a ground, primary current would flow back through the interrupter switch to the solenoid, and the solenoid would become energized.
AS SOON AS THE SOLENOID BECAME ENERGIZED it would open the ball valve, dumping the oil.

With no pressure behind the piston, it would move back, opening the contacts in the interrupter switch. The ball valve would again close because the solenoid would then be de-energized. Hydraulic pressure would move the piston forward until it again closed the contacts in the interrupter switch. The solenoid would immediately become energized, the oil pressure would drop, and the piston would move back, and the cycle would start all over again.

The result would be that the piston would "shuttle" back and forth, and wouldn't complete the upshift until the oil pressure became high enough to push the piston past the interrupter switch fast enough so the cycle couldn't take place.

But, with the resistor in the circuit, a feed-back of primary current is prevented, and the upshift can be made smoothly and quickly.
The Shuttle Valve

The shuttle valve is mounted in the transmission extension directly below the pump. It's really a safety valve, and works only when something happens to prevent the solenoid from opening the ball valve and relieving the oil pressure against the piston.

Ordinarily, the shuttle valve is held down by oil pressure so it blocks off a drain port leading to the sump. But, if the car comes to a quick stop, or the engine stalls and for some reason the solenoid doesn't become energized to push the ball valve off its seat and dump the oil, the transmission wouldn't downshift until that oil pressure was relieved. That's where the shuttle valve comes into action.

As soon as the pump stops, the oil pressure on the top of the shuttle valve is relieved. The shuttle valve is pushed up by a spring, uncovering the passage to the sump. The oil behind the piston immediately drains away, allowing the piston to return to the downshift position.
During ordinary operation, the shuttle valve has nothing to do with the operation of the transmission. But, if someone has had the shuttle valve out for some reason or other, and didn't get all the parts back in, it would have an effect. So, if you happen to get a case where the transmission is slow to upshift, take a look at the shuttle valve to see that it is all there, and the parts are in the right position.

**The Engine Helps The Brakes**

On normal grades, the hydraulically operated transmission provides engine braking, just as any other transmission. However, if the driver wants greater braking power from the engine on an unusually steep hill, he can shift into second speed. Second gives the best gear ratio for engine braking.

In order to shift from fourth speed to second, the driver pushes in the clutch pedal, moves the gearshift lever to "power" range, and lets the clutch pedal up. Of course, he must be driving faster than six miles an hour or the transmission will shift into first, with no engine braking.

If the driver happens to start down a hill in first speed, all he has to do is push the clutch pedal in when the car speed is above six miles per hour, and then release the clutch. The transmission then automatically upshifts into second.

**Pushing To Start**

In order to start the engine by pushing, the driver simply puts the gearshift lever in either driving range or power range. He holds the clutch pedal in and turns the ignition on. If he's using driving range, he releases the clutch pedal when the car reaches a speed of about thirteen miles an hour. In the power range he'd release the clutch at about six miles an hour.
THE POWER FLOW STORY

In order to have a constant mesh transmission with four forward speeds, it is necessary to have a constant mesh gear on the countershaft that can drive or coast, as the speed positions require.

In the hydraulically operated transmission, the countershaft constant mesh gear is the first gear of the countershaft gear assembly. This constant mesh gear rides on the hub of the countershaft gear, and is in constant mesh with the main drive pinion.

Its operation might be compared to the operation of the coaster brake on a bicycle. When the constant mesh gear is being driven by the main drive pinion, it drives the countershaft gear. But when the countershaft gear is being driven faster than the constant mesh gear, as it is when the car decelerates, the constant mesh gear turns, but doesn’t drive anything. In other words, the constant mesh gear “coasts” when its hub is being driven faster than the gear.

IT’S DONE WITH ROLLERS

The connection between the constant mesh gear and the hub of the countershaft gear is made through the over-running clutch rollers. The hub on the countershaft gear is provided with ramps, or cams.

When the countershaft gear is being driven faster than the constant mesh gear, the rollers move down to the low sides
of the cams. Then there is no rigid connection between the gear and the hub.

But, when the constant mesh gear is driving the counter-shaft gear, the rollers are forced up on the high sides of the cams and wedged between the hub and the gear, forming a rigid connection.

**POWER FLOW IN FIRST SPEED.** In first speed, the manual clutch gear sleeve is moved back to couple the first speed gear to the main shaft. The power flow is through the main drive pinion, the constant mesh gear, the countershaft gear, the first speed gear, the manual clutch sleeve and gear, and out the main shaft.

During deceleration, the power flow is reversed. This causes the first speed gear to drive the countershaft gear faster than the constant mesh gear is being driven by the main drive pinion. Therefore, with the hub of the constant mesh gear being driven faster than the gear itself, the over-running clutch rollers drop down to the low sides of the cams. This action disconnects the gear from the hub, so the gear turns but doesn’t drive the pinion. Since the constant mesh gear is not being driven by the countershaft gear, torque is not transmitted to the main drive pinion and the car cannot decelerate against engine compression.
THE CONSTANT MESH GEAR CONTROL SLEEVE. When the transmission upshifts to second speed, the direct speed piston and shift fork move the direct speed clutch sleeve forward, coupling the third speed gear to the main drive pinion. As the sleeve moves forward it carries the constant mesh gear control sleeve with it. As the control sleeve moves forward, the lugs on the overrunning clutch roller retainer are engaged in the slots in the sleeve, giving a slight cam action to the retainer.

This cam action rotates the overrunning clutch roller retainer, moving the rollers to the low sides of the cams. When on the low sides of the cams, the rollers do not form a rigid connection between the constant mesh gear and the hub on the countershaft gear. Therefore, the constant mesh gear “coasts,” so the third speed gear can drive the countershaft gear.
POWER FLOW IN SECOND SPEED. In second speed, then, the direct speed clutch sleeve couples the main drive pinion to the third speed gear. Power flow is through the main drive pinion, the third speed gear, the countershaft gear, the first speed gear, the manual clutch sleeve and gear, and out the main shaft. Notice that in this speed the power flow by-passes the countershaft constant mesh gear.

When the car decelerates in second speed, the power flow is reversed. In this speed, however, the power flow acts against engine compression because the direct speed clutch sleeve is connecting the third speed gear to the main drive pinion. Therefore, the engine acts as a brake.
POWER FLOW IN THIRD SPEED. In third speed, the manual clutch gear sleeve is moved forward to couple the third speed gear to the main shaft. The power flow is through the main drive pinion, the constant mesh gear, the countershaft gear, the manual clutch sleeve and gear to the third speed gear, and out the main shaft.

When the car decelerates in third speed, the third speed gear drives the countershaft gear faster than the constant mesh gear is being driven by the main drive pinion. Therefore, as in first speed, the constant mesh gear cannot transmit torque to the main drive pinion, and the car cannot decelerate against engine compression.
POWER FLOW IN FOURTH SPEED. In fourth speed, the direct speed clutch sleeve couples the third speed gear to the main drive pinion. The third speed gear is also connected to the main shaft by the manual clutch gear and sleeve. The power flow is straight through, by-passing the countershaft gear.

When the car decelerates in fourth speed the power flow is reversed and acts against engine compression.

REVERSE GEAR ARRANGEMENT. The reverse gear arrangement in this hydraulically operated transmission differs from the conventional three-speed transmission in one major point—the reverse idler gear is a sliding gear.

The reverse idler gear is in constant mesh with the first speed gear of the countershaft gear. When the transmission is shifted to reverse speed, the idler gear is moved back to connect the countershaft gear to the reverse gear on the main shaft.
POWER FLOW IN REVERSE SPEED. In reverse speed, the power flow is through the main drive pinion to the constant mesh gear, through the countershaft gear to the reverse idler gear, up to the main shaft reverse gear, and out the main shaft.

![Diagram of reverse gear]

When the transmission is shifted into reverse, the reverse idler gear slides back to connect the countershaft gear to the reverse gear on the main shaft. Power flow is through the main drive pinion to the constant mesh gear, through the countershaft gear to the reverse idler gear, up to the reverse gear, and out the main shaft.

SUMMARY OF POWER FLOW

To review the power flow story briefly, keep in mind these important points. When the constant mesh gear is in the power flow, as in first and third speeds, the drive can be only one way. In other words, the engine can drive the rear wheels, but the rear wheels cannot drive the engine.

When the constant mesh gear is not in the power flow, as in second and fourth speeds, the drive can be both ways. The engine can drive the rear wheels, and the rear wheels can drive the engine.

That is why second speed should be used as an aid to braking on very steep grades—and why second speed is the best speed to use when pushing the car to start the engine.
# Test Yourself
## With These Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>1. The manual clutch gear sleeve connects either the first speed gear or the third speed gear to the main shaft through the manual clutch gear.</td>
<td>Right</td>
</tr>
<tr>
<td></td>
<td>Wrong</td>
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<td>2. The direct speed clutch sleeve couples the third speed gear to the main drive pinion.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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<tr>
<td>3. The governor is like an automatic switch. It completes or breaks the circuit to the solenoid.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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<td>4. The purpose of the ignition interrupter switch is to interrupt or break the ignition circuit during the downshift operation of the transmission.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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<td>5. The units of the transmission electrical circuit are protected from damage by shorts or grounds by: (check one)</td>
<td>Fuse</td>
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<td></td>
<td>Circuit</td>
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<td></td>
<td>Breaker</td>
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<td>6. The twelve-ohm resistor on the circuit breaker bracket has no effect on the operation of the transmission.</td>
<td>Right</td>
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<td>Wrong</td>
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<td>7. If the driver wants to use engine compression as an aid to braking on a steep hill, he shifts the transmission to third speed.</td>
<td>Right</td>
</tr>
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<td></td>
<td>Wrong</td>
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<tr>
<td>8. The constant mesh gear control sleeve is moved forward and backward by the direct speed clutch sleeve.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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<tr>
<td>9. When the constant mesh gear is in the power flow (first and third speeds) the engine cannot be used as a brake.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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<td>10. The reverse gear on the main shaft slides into mesh with the reverse idler gear when the transmission is shifted into reverse.</td>
<td>Right</td>
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<td></td>
<td>Wrong</td>
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</table>
WHAT GOES ON INSIDE
THE HYDRAULICALLY OPERATED
TRANSMISSION?

EXPIRATION DATE NOVEMBER 30, 1949
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The manual clutch gear sleeve connects either the first speed gear or the third speed gear to the main shaft through the manual clutch gear.

The direct speed clutch sleeve couples the third speed gear to the main drive pinion.

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The units of the transmission electrical circuit are protected from damage by shorts or grounds by: (check one)

The twelve-ohm resistor on the circuit breaker bracket has no effect on the operation of the transmission.

If the driver wants to use engine compression as an aid to braking on a steep hill, he shifts the transmission to third speed.

The constant mesh gear control sleeve is moved forward and backward by the direct speed clutch sleeve.

When the constant mesh gear is in the power flow (first and third speeds) the engine cannot be used as a brake.

The reverse gear on the main shaft slides into mesh with the reverse idler gear when the transmission is shifted into reverse.
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