TECH SEZ:

If you look closely enough at even the most complicated mechanism, you usually find that it turns out to be just a lot of surprisingly simple units, all working together.

The Hydraulically Operated Transmission is a good example of that fact. Sure, it shifts up at one car speed, merely with the lift of the accelerator pedal, and it shifts down automatically at another car speed. It lets you do 98% of your driving by just steering, without doing anything else except stepping on the gas to go and on the brakes to stop. It sounds as though it would take a mighty complicated mechanism to do all that.

But the beauty of this transmission is how much it does with just one simple shift mechanism. It all boils down to a single connecting sleeve between two gears in the transmission. When it's moved ahead you're in the driving gear, and when it's back you're in the starting gear. An oil pump and a piston provide the force to do the automatic shifting and an electrical system controls the timing of the shift. When the current's on, you're in the lower gear. When the current's turned off, you're all set to shift into the higher gear when you let up on the gas for a second.

So don't let the if's, and's, and but's throw you... because underneath, the transmission's just as simple as that.
STARTING WITH FUNDAMENTALS

In the first place, let's clear up the idea that there's anything complicated in the transmission itself... there isn't.

Instead, it's essentially a conventional unit of the constant mesh type. That means that the shifting in this sort of transmission is done, not by moving the gears, but by moving shift sleeves that either connect or disconnect the gears from the main shaft.

There are four forward speeds available in this transmission—first, second, third and high. With the gearshift lever in the upper, or power range, you use first and second only. Moving the lever down to the lower position, the driving range, gives you third and high. Because third speed gives ample getaway for most conditions, 98% of the driving is done in the driving range, using just two speeds—third and high. It will be easier to follow the explanation of the automatic operation of the transmission if we start it with the driving range only.

ONE SLEEVE MAKES THE AUTOMATIC SHIFT

The automatic operation of the transmission makes the shift up or down between third and high, with no manual effort by the driver. The change is made simply by moving the one automatic clutch
sleeve back or forward inside the transmission, so either you disconnect the main drive pinion from the main shaft, or you connect it. In the driving range, when the automatic clutch sleeve is back, there's no connection between the pinion and the main shaft except around through gears, so you're in third. When it's moved ahead, the drive is straight through, so you're in high.

To make the shift from one speed to the other automatically, we need power to move the sleeve. That's done with a hydraulically operated piston and an engaging spring for the upshift and by the piston return spring for the downshift. To turn the hydraulic system on or off we add an electrical control system.

Then, to have the shift called for at the proper car speed, we turn the electrical control system on or off with a centrifugal governor run off the countershaft gear cluster in the transmission. At ordinary speeds above the governor setting, the driver can take over control of the transmission with a "kick-down" switch, operated by pushing the accelerator pedal to the floor.

**THE HYDRAULIC SYSTEM**

There's a rotor-type oil pump, right in the transmission, to build up the hydraulic pressure. It's driven from the main shaft, so it operates only when the rear wheels are turning. To control maximum oil pressure, there's a relief valve in the system. When
the pressure is high enough to lift it off its seat, the excess oil can return to the transmission case.

A combination of two valves is used to keep hydraulic pressure on or off the piston. The smaller of the two is called a pilot valve, and is electrically controlled by a solenoid. What it does is to control the opening and closing of the main hydraulic valve by admitting or cutting off the oil pressure beneath the main valve.

As shown in the diagram, when the pilot valve is held down (by the plunger in the solenoid) it cuts off the flow of oil under pressure from the oil passage that leads to the bottom of the main valve. With no pressure to force it up, the main valve is held down by its coil spring. In this position it shuts off the flow of oil under pressure to the piston.

**UP FOR UPHSHIFT**

When the pilot valve is *not* being held down by the solenoid, the spring beneath it pushes it up, as shown in the next illustration. That opens up the lower oil passage, so that oil under pressure can lift the main valve up. When that happens, oil can go directly to the piston, pushing it ahead.

Moving the piston ahead for the upshift compresses two springs. The larger one is the piston return spring, which will move the piston back as soon as the oil pressure is relieved. The smaller spring is the engaging spring. This is the spring that actually makes the
mechanical shift. The spring is cocked for action when the piston is pushed ahead. It pushes against the shift fork that moves the automatic shift sleeve. But the sleeve can’t move ahead until the engine speed drops down to match the shaft speed. So the actual shift doesn’t take place until the driver lifts his foot off the accelerator pedal for a moment. When he does, the blocker ring lines up and no longer holds back the sleeve, so the sleeve, fork and rail are moved ahead by the engaging spring and the transmission is in high.

**DOWN FOR DOWNSHIFT**

The downshift occurs when the hydraulic pressure is shut off from the piston. To do that the pilot valve must be pushed down, cutting off oil pressure to the passage beneath the main valve. That lets the main valve be pushed down by its spring to shut off the flow of oil to the piston. With no oil pressure to hold it forward, the piston is immediately pushed back by the large return spring. On its return, it moves the rail and shift fork back also. That pulls the automatic clutch sleeve back off the main drive pinion to the third speed position. As long as power is being delivered through the automatic clutch sleeve there will be too much pressure between the sleeve and the splines on the pinion to let the sleeve slide off easily. To take care of that situation an interrupter switch, closed momentarily by the returning piston (as explained later) cuts off the engine ignition system just long enough.
to let the sleeve be pulled away from the gear. Once the sleeve is free from the main drive pinion, the downshift is completed.

THE ELECTRICAL SYSTEM
THE SOLENOID

The electrical unit which actually controls the hydraulic system is the solenoid. It's mounted directly over the pilot valve. This unit has a plunger which is forced out (or down) when the current is turned on.

That means that when the current to the solenoid is turned on, the plunger pushes the pilot valve down, with the end result that the transmission shifts to the lower of the two speeds automatically available. If the current to the solenoid is turned off, the plunger is no longer pushed down, so the spring beneath the pilot valve can push it up. With the pilot valve open, oil raises the main valve and can then push the piston ahead, cocking the engaging spring for the upshift.

It boils down to this ... if the current to the solenoid is turned on, the transmission is in third. If the current to the solenoid is turned off, the transmission is ready to shift to high.

IN THIRD FOR STARTING

The transmission should be in third gear for starting, so that means the solenoid should be turned on. When the ignition is turned on, current for the solenoid
comes direct from the battery, through an electrically operated switch, called a relay. An electromagnet in the relay holds the contact points in the relay closed as long as current is going through the magnet. (If the current is turned off, a spring pulls the contact arm up, separating the contacts and breaking the circuit from the battery to the solenoid).

As you can see by the illustration, there are actually two sets of contacts in the relay. The current for the solenoid goes through the shorter contact arm, which is insulated from the steel plate. The second arm has nothing to do with the solenoid circuit, but completes the ignition circuit to the interrupter switch, as will be explained later.

Current for the solenoid, as well as for the electromagnet in the relay comes to the battery (or fuse) terminal of the relay. If the coil of the electromagnet is grounded, through the TH terminal of the relay, the current goes through the magnetic coil, magnetizing the core and pulling the contact arms down.

That closes the relay contacts so current from the battery can go directly through the copper contact arm to the solenoid terminal of the relay and from there to the solenoid.

With the solenoid turned on, the pilot valve is being held down. That means that there's no oil pressure on the hydraulic piston, so the transmission is in third ... the speed we want for starting or for extra acceleration.
THE UPHSHIFT FROM THIRD TO HIGH

Turning the solenoid off, when the car speed is fast enough to use high gear, is done by the governor. As you can see from the circuit diagram, the current that energizes the magnet coil in the relay goes through a set of contacts in the governor on its way to ground. When the car is starting, or going slowly, a plunger in the governor holds the governor contacts closed. As long as they are closed, the contacts in the relay will also be held closed, by the pull of the electro-magnet. But as the speed of the car increases, the weights in the governor whirl around faster and are thrown outward.

At a car speed of about fourteen miles an hour the weights pull the plunger away from the switch arm and a spring pulls the contacts apart. With the governor contacts open, there’s no longer any ground connection for the electro-magnet coil in the relay, so no current flows through it. With no magnetic force to hold it down, the contact arm in the relay springs up, separating the contacts and shutting off the current from the battery to the solenoid.

With the solenoid turned off, the pilot valve is pushed up by its spring, the main valve lifted by hydraulic pressure and the hydraulic piston is moved ahead. That compresses the engaging spring, (which will complete the upshift whenever the driver lifts his foot) off the accelerator for a second.
THE DOWNSHIFT WHEN CAR SPEED DROPS

When the car slows down to below about eleven miles an hour in high, the transmission automatically shifts itself down to third speed. Here again it's the governor that calls for the shift. The weights are no longer thrown out far enough to pull the plunger down, so it again pushes the governor contacts closed. That completes the circuit through the electromagnetic coil in the relay to the ground. With current again flowing through the coil, the magnetic force pulls the contact arms in the relay down closing the contacts. The circuit from the battery to the solenoid is thus completed and the solenoid is turned on, or energized.

Turning the solenoid on pushes the pilot valve down which lets the main valve get pushed closed by its spring. Hydraulic pressure no longer holds the piston ahead, so the return spring starts to push it back. The actual shift is made by the piston pushing the shift rail and the fork back with it. The fork pulls the automatic shift sleeve free from the main drive pinion. But as explained before, as long as the sleeve is transmitting power from the engine, it won't slide off the splines on the pinion. That's where the interrupter switch comes in . . . to cut off that engine power for an instant.

The interrupter switch is mounted in the transmission case directly
over the piston. As the piston is moved back under the switch, the wall of the piston raises a ball that closes the contacts inside the interrupter switch until the piston has passed. One of the contacts is grounded and the other is connected to the terminal on the top of the switch. That means that when the contacts are closed, the wire coming to the interrupter switch is grounded.

Looking at the circuit diagram you can see that when the relay contacts are closed, as they are for the downshift there's a direct connection between the ignition terminal on the ignition coil and the interrupter switch terminal. So, when the terminal is grounded by the interrupter switch contacts being closed, the entire ignition system is grounded or shorted out. The hydraulic piston is under the switch for only an instant, but it's long enough to cause the engine to miss about two explosions. That's enough break in the power for the sleeve to be slid off the pinion, to make the shift to third.

(NOTE: The interrupter switch can ground the ignition system only when the relay contacts are closed. On the upshift the relay contacts are open. That's why there's no momentary power interruption on the upshift, even though the interrupter switch contacts are closed as the piston moves ahead under the switch. A groove in the piston lets the ball drop down to open the contacts when the piston is in the high speed position.)
THE DOWNSHIFT FOR EXTRA ACCELERATION (KICKDOWN)

There are times in ordinary driving, or when passing a truck or slower moving car in the middle of a long hill, when the driver wants extra power for acceleration. He'd like to be in third, but at the speed he's going, the governor points are open. To meet that situation a special "kickdown" switch is built into the carburetor, so that when the accelerator pedal is pushed down to the floor, the throttle linkage will close the switch. With the switch closed, the electro-magnet in the relay is grounded and current flows through it just the same as though the governor points were closed. That turns the solenoid current on and calls for the downshift immediately and automatically.

Locating the kickdown switch in the carburetor makes it possible to put the switch out of action at car speeds above forty to forty-five miles an hour. At such speeds, shifting down to third would hinder rather than help.

The illustrations show how the switch is built to go out of operation at high speeds. The actual contact with ground is made when the switch plunger is pushed in against a metal spacer, forcing it against the switch terminal contact. The spacer is mounted on a small piston which at faster speeds is pulled up by the high velocity flow through the carburetor. When
that happens, the spacer no longer lines up with the contact, so there’s no ground when the plunger pushes it forward.

**AUTOMATIC SHIFTING IN THE POWER RANGE**

Automatic operation of the transmission is exactly the same in the power range (first and second) as in the driving range. The same automatic shift sleeve is moved forward or back by the same hydraulic piston engaging spring and return spring. The only difference is that the manual clutch sleeve is moved back instead of ahead, so the two lower gears go into operation. That also means that the automatic shifts are at lower car speeds. The upshift is at about seven miles an hour and the downshift at around six miles an hour.

**WHY TWO FREE-WHEELING SPEEDS?**

Two of the speeds in the transmission, first and third, must be through a free-wheeling gear in order to have a constant mesh transmission. With power going through a free-wheeling gear, the drive can be just one way... the engine can drive the rear wheels but the rear wheels can’t turn the engine. Therefore, engine compression as an aid to braking isn’t available in either first or third.
**HOW THE FREE-WHEELING GEAR WORKS**

The free-wheeling gear is one which has a series of rollers between the gear itself and the hub on which it runs. The hub itself is not perfectly round, but instead provides a series of ramps for engaging the rollers. When the gear is doing the driving, the rollers are moved up the ramps until they wedge between the gear and the hub. From then on the gear drives the hub. But if the hub is turned faster than the gear, or if the hub turns while the gear is standing still, the rollers come down the ramps so the gear is free and cannot be turned by the hub.

**HOW THE FREE-WHEELING GEAR IS USED**

The use of the free-wheeling gear will be easier to understand if we trace the power flow through the transmission in each speed.

**FIRST SPEED**

In first speed the direct speed clutch sleeve (that’s the one that is automatically moved by the hydraulic piston) is held back. That means there’s no connection between the main drive pinion and the third speed gear. As a result, the power goes down through the
free-wheeling gear. This gear is always in mesh with the main drive pinion and is located on the forward end of the countershaft. With the gear being driven the rollers wedge against the hub, which is a part of the countershaft cluster gear. So the hub and the gears are driven by the free-wheeling gear.

The third speed gear on the cluster is in mesh with the third speed gear on the main shaft. But with both the automatic and the manual clutch sleeves moved back, the third gear is entirely separated from the main shaft. That means the third speed gears are turning, but not driving anything.

As a result, power goes all the way back to the first speed gear, which is locked to the main shaft by the manual clutch sleeve.

The principal point to remember is that the power flow is going through the free-wheeling gear, so the drive can be only one way. The engine can drive the rear wheels, but coasting or pushing the car in first cannot turn the engine over. Instead, the rollers in the free-wheeling gear merely loosen up, freeing the gear from the hub.

**SECOND SPEED**

The shift to second speed is made by moving the automatic clutch sleeve forward so it connects the third speed gear to the main drive pinion. Because of the difference in gear ratios, the third speed gear drives the countershaft gear cluster faster than the free-wheeling gear is turning. The rollers make this possible by freeing the hub from
the gear. The free-wheeling sleeve, which is moved up with the automatic clutch sleeve, helps this operation. It moves the cage and rollers back from the wedged position and maintains a positive disengagement.

As before, the power goes out through the first speed gear, but this time it has by-passed the free-wheeling gear. So, in second, with power going only through gears that are locked to the shafts, the drive can be both ways . . . the engine can drive the rear wheels and the rear wheels can turn the engine. That's why second is the speed to use if you want to use engine compression as an aid to braking on a particularly steep, long downgrade. It's also the best speed to use if it is ever necessary to push the car to start the engine.

**THIRD SPEED**

In third speed the automatic clutch sleeve is again moved back, separating the main drive pinion from the third speed gear. So the drive is once more down through the free-wheeling gear, as shown. In this case, with the manual clutch sleeve moved ahead also, the third speed gear is connected to the main shaft and the first speed gear is running free. So the third speed gear drives the shaft. But remember, with the free-wheeling gear in the power flow, the drive can be just one way, as it was in first speed.

**FOURTH SPEED**

In fourth speed the automatic clutch sleeve is moved ahead, con-
necting the third gear to the main drive pinion. The third gear is also connected directly to the mainshaft, by the manual clutch sleeve, so the drive is straight through, bypassing the free-wheeling gear and the entire gear cluster, which turns but doesn't drive anything. With the power going only through gears connected directly to the mainshaft, the drive is again in either direction.

**USING ENGINE COMPRESSION AS AN AID TO BRAKING**

If an owner feels he isn't getting the engine braking he should have on particularly steep hills, he probably needs instruction in putting the transmission in the proper gear.

Actually it's very simple. If he's going downhill at more than fourteen miles an hour, in high, all he needs to do is to step on the clutch and move the shift lever to the power range. As soon as he lets the clutch pedal out, he'll be in second with plenty of engine compression available. If he starts down the hill in the power range, he'll automatically be in second if he pushes the clutch pedal long enough for the transmission to upshift, as soon as the car speed reaches about eight miles an hour.

**PUSHING THE CAR TO START**

The power range, using second gear, is preferable to use if the car
is to be started by pushing. That's because a shorter distance and slower car speed will be needed. The best procedure is to put the lever in the power range, turn the ignition on and hold the clutch pedal down (to make it easier for the car doing the pushing). As soon as the car speed goes over eight miles an hour, let up on the clutch. The transmission will automatically be in second and the rear wheels will start turning the engine over.

**A QUICK REVIEW**

The two diagrams (pgs. 20 and 21) of the entire electrical and hydraulic systems of the transmission can be used for a quick review of what happens for the downshift and for the upshift.

**DOWNSHIFT**

For this, the car speed is *down*, or the accelerator pedal is *down* to the floor (for a kickdown). In either case, the ground circuit is completed to the electro-magnet in the relay. That pulls the contact arm *down*, which completes the circuit to the solenoid. With the current turned on, the solenoid plunger is forced *down*, pushing the pilot valve *down*. As a result, the main valve is pushed *down* by its spring and the oil pressure at the piston immediately drops *down*. As you can see, for downshift, everything's *down*.

With no pressure on the piston the return spring pushes it back. The piston brings the shift rail and the shift fork back with it, shifting the
transmission to third (or first). On its way back, and to loosen the sleeve from the pinion, the piston shorts out the ignition system momentarily, by raising the contacts in the interrupter switch.

**UPSHIFT**

For the upshift, the car speed is up far enough for the governor points to open up. That breaks the ground circuit to the relay magnet so the contact arm goes up, breaking the circuit to the solenoid. With the current off and the solenoid plunger no longer being forced down, the spring beneath the pilot valve can push both the valve and the plunger up. That let's oil push the main valve up and open. As a result the oil pressure is up on the piston, so it's pushed ahead. So, everything's up for upshift.

The piston return spring and the smaller engaging spring are both compressed by the piston movement. Now the upshift will be made by the engaging spring pushing the rail and the shift fork ahead, as soon as the driver lifts his foot off the accelerator pedal.
COMBINED OPERATIONS—UPSHIFT POSITION

(FOURTH SPEED)
COMBINED OPERATIONS—DOWNSHIFT POSITION

(THIRD SPEED)
TEST YOURSELF
WITH THESE QUESTIONS

1. For the upshift, both hydraulic valves are up (open).
   - TRUE □
   - FALSE □

2. The current for the solenoid goes through the shorter contact arm in the relay.
   - TRUE □
   - FALSE □

3. When the piston is in the rear position the upshift is completed.
   - TRUE □
   - FALSE □

4. The interrupter switch can short out the ignition system only if the relay points are open.
   - TRUE □
   - FALSE □

5. The governor turns the relay magnet off by breaking the circuit to ground.
   - TRUE □
   - FALSE □

6. When the solenoid current is on, the hydraulic pressure is on the piston.
   - TRUE □
   - FALSE □

7. The engaging spring moves the shift rail and shift fork to move the automatic clutch sleeve in the transmission.
   - TRUE □
   - FALSE □

8. In third (or first) the automatic shift sleeve is moved ahead to engage with the main drive pinion.
   - TRUE □
   - FALSE □

9. To take advantage of engine compression for braking, use third speed.
   - TRUE □
   - FALSE □

10. For the downshift, the solenoid is energized.
    - TRUE □
    - FALSE □
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... A real trouble shooting session