Mitsubishi Electronically Controlled Suspension System

The 1989 Mitsubishi Galant GS has an electronically controlled, and very sophisticated, pneumatic suspension system. Mitsubishi has offered this option in one form or another since the 1985 model year. The current system keeps track of many changes in driving conditions, load conditions, and driver inputs. The system's ECU processes this information, plus driver selected modes of operation. It then combines variable shock damping and a compressed air system to control ride height. If this seems pretty mind boggling, it is. The good folks at Mitsubishi were kind enough to send us a manual on the system, and believe me, it's not short. But there is a logic involved. Like many of the newer systems found on ''modern'' vehicles, it uses the ever-present computer to sort out all this information. The computer, or ECU, then sends an electrical message to electro-mechanical switching devices that control air flow to the suspension. Applying or releasing air, it compensates for the effects of inertia and gravity.

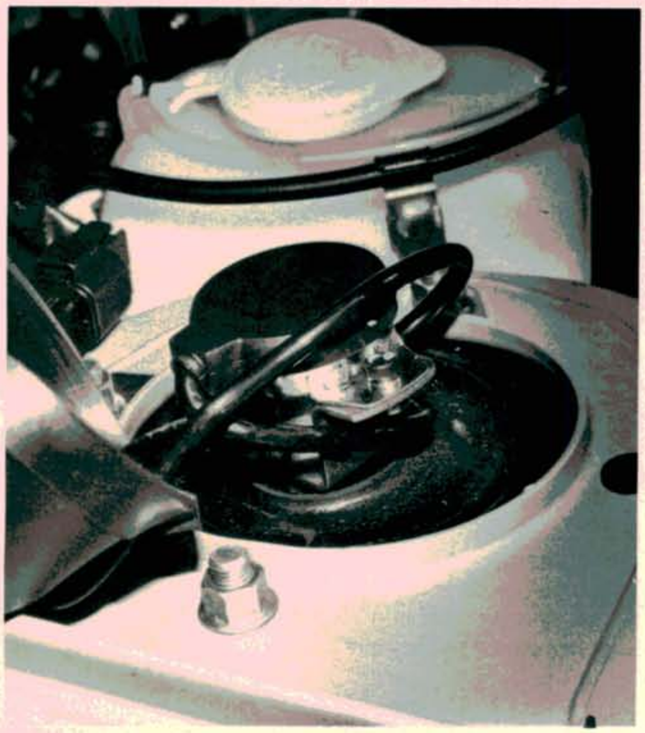
It Does What?

If you ever cranked up the tension on the springs of your old motorcycle, you have some basic idea of what it means to adjust ride control. Unfortunately, stiffer springs usually require more damping, and so on.

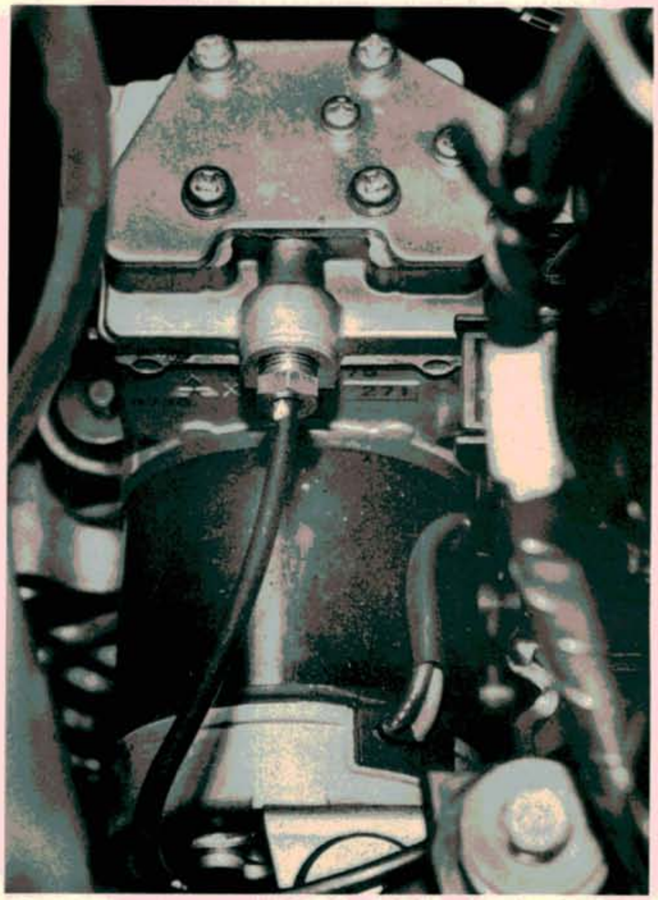
And we all remember those times when we packed the back seat and trunk with mom and the kids and three or four tons of camping equipment, only to find that we *really* had power steering as the nose of the car pointed skyward. (I didn't mean to suggest that mom was in the trunk.)

Ride height is just as important to suspension operation as springs and shocks. This is important to linear stability as well as minimizing body roll when cornering.

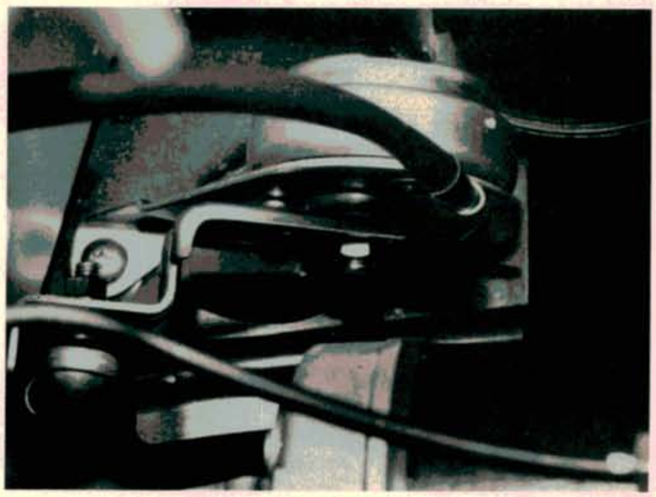
And what about body pitch during hard acceleration or braking? There's no denying the effects of inertia and gravity at times like this. The suspension system on the GS takes all of this into account when adjusting the suspension.



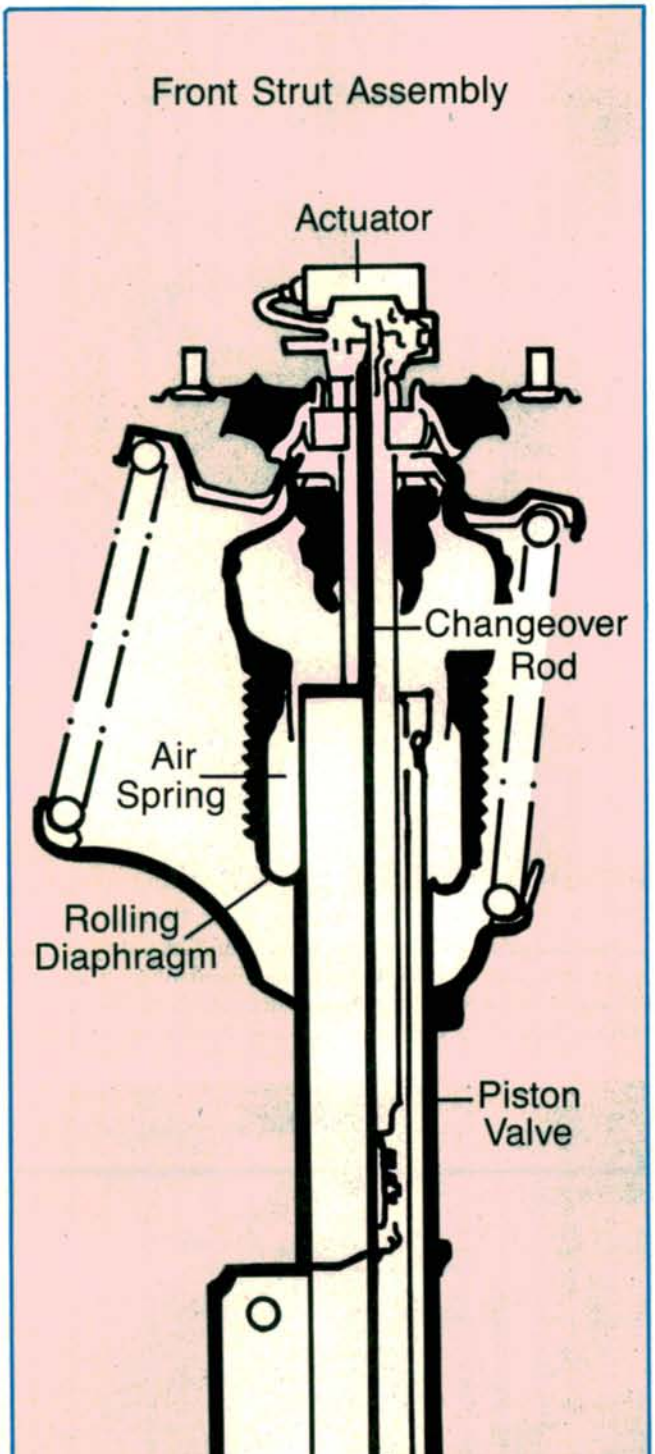
The Galant GS has front struts and rear shocks. Each has its own actuator containing a stepper motor. The ECU uses the motor to move the actuator changeover rod to one of four positions. This provides HARD, MEDIUM, AUTO-SOFT, or SOFT shock damping.



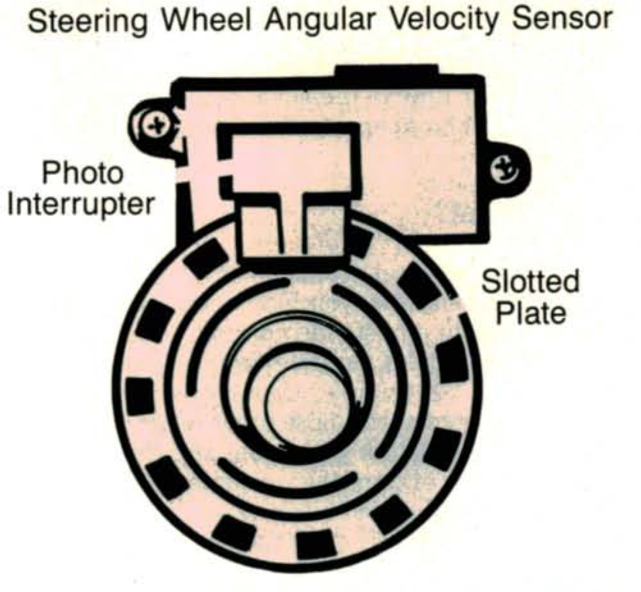
The air compressor is located just above the transaxle in the engine compartment, and looks a bit like a starter. The guts of the system, it provides compressed air to inflate air springs in the struts and shocks. This maintains the desired vehicle height for different load and driving conditions.



Here's the front vehicle height sensor, located near the air compressor. There are two sensors, one for the front, one for the rear. A rod hooked to the suspension moves a disc plate that interrupts the light from an LED as it passes to a photo-transistor. This message tells the ECU about ride height.

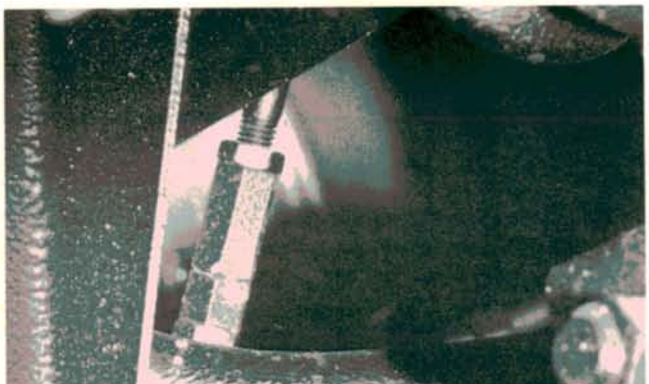


The strut assemblies use a rolling rubber diaphragm to form an air chamber. Air is supplied to this sealed chamber through a hole in the piston rod. Compressed air enters or vents through this hole, controlling ride height.



The steering wheel angular velocity sensor is located below the steering wheel. A slotted wheel passes between two photo-transistors. The sensors are stationary. The slotted wheel turns with the steering shaft.

Turning the steering wheel turns the disc, and the speed with which the slots pass the photo-transistor is sent as a message to the ECU.



A rod connects the control arm to the disc plate in the ride height sensor. Each rod has a turnbuckle allowing for its precise adjustment. As loads increase, the control arm moves upward. This moves the rod upward, rotating the disc plate. The ECU then inflates or deflates the shocks to maintain desired vehicle height.

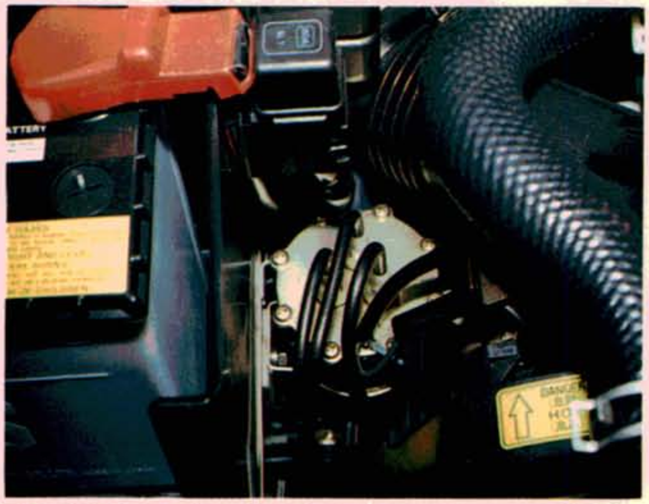
But How?

There are quite a few components working with the ECU to keep this system working. Here's a list of major components. They monitor vehicle speed, loads applied to the suspension, rates of lateral acceleration (turning), and the rates of linear vehicle acceleration or braking.

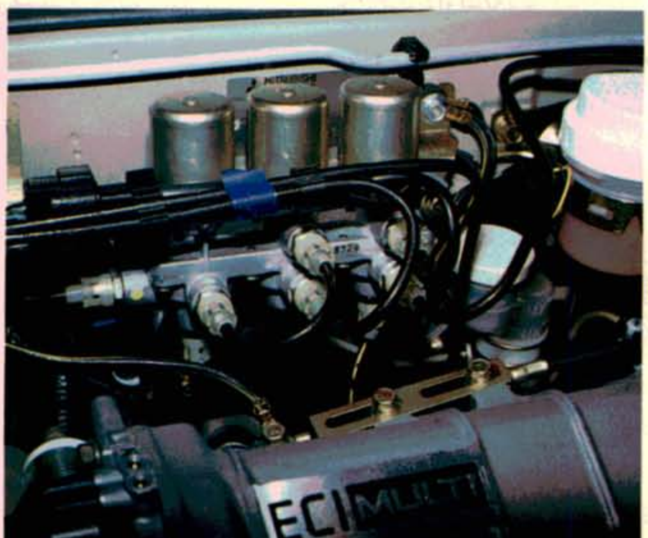
• **Vehicle Speed**—The speed sensor in the speedometer head provides information to a number of systems, including fuel injection, the automatic transmission, and the cruise control.

• **Steering Wheel Angular Velocity**—In simple terms, this sensor in the steering column tells the ECU how fast the steering wheel was turned to warn the ECU that the driver wants to change directions—in a hurry.

• **The Lateral G Sensor**—This sensor informs the ECU of lateral body movement, or roll.
• **Throttle Position Sensor**—Like the vehicle speed sensor, the TPS provides information to more than one system. The ECU needs to know the intended rate of acceleration to keep the car level during fast starts.
• **The Reserve Tank**—This tank has separate low and high pressure chambers. The high pressure side provides air to the air shocks. The low side accepts vented air from the shocks. A return pump compresses low side air and pumps it to the high side chamber. The tank is fitted with two pressure sensitive switches. The high pressure switch will turn off the main compressor if high side pressures get too high. The low side switch controls the return pump.
• **Compressor Relay**—When pressure in the high side of the reserve tank drops too low, the switch closes, activating the compressor relay.
• **Damping Force Changeover**—A rotary valve in each shock or strut has four separate orifice openings—two large and two small. When the changeover rod rotates, one of four different damping combinations can be obtained.



The drier is similar to the drier in an air conditioning system. It's located next to, and just below, the battery. It serves two functions. First, it removes potentially damaging moisture from the system. Second, it has a one-way valve that traps system pressure if the compressor quits.



The flow control solenoid valve is located on the firewall. It regulates the amount of air passed to the front and rear control solenoid valves. Air flow depends on the speed with which adjustments in air pressure to the front and rear solenoids have to be made.

The Indicator Control Panel

The Indicator Control Panel accepts messages from the driver to the ECU. One button allows the driver to control vehicle height by selecting HIGH, NORMAL, or LOW ride height. The other three buttons control damping for SPORT, SOFT, or AUTO operation. Ten green lights illuminate to inform the driver which mode has been selected. A red alarm light informs the driver of a system malfunction.

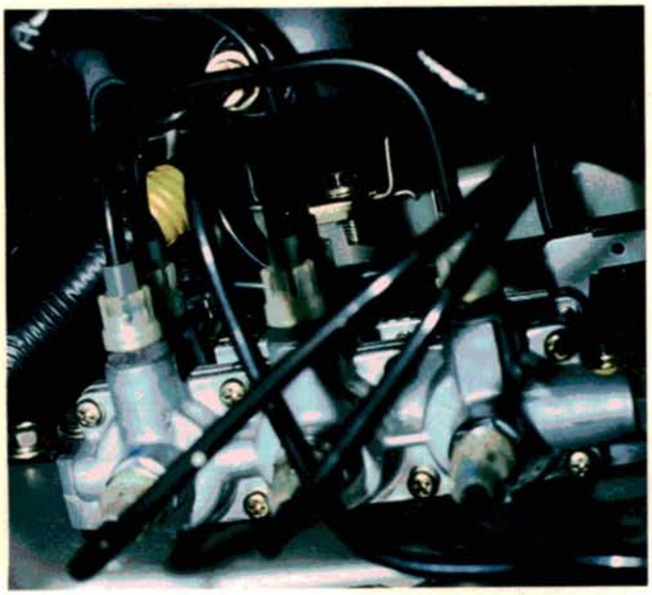
Once the driver selects a target height for the vehicle, the ECU adjusts the front and rear suspensions separately. There is a 40 mm difference in vehicle height between the LOW and HIGH settings. That's NORMAL setting plus or minus 20 mm.

Not Just Another Pretty Face

Before someone out there decides that the air shocks on your old truck do the same things, let's look at all the corrections the ECU can make.

The ECU has a list of priorities when it comes to ride control that supplement and occasionally override selected modes of operation. These priorities are listed in order of importance.
• **SPORT Switch**—In this position, shock damping is always set to HARD.

• **Anti-roll Control**—When the ECU receives messages from the G sensor and the steering angular velocity sensor, it knows the car is turning. It compensates for body roll by increasing air pressure in the shocks at the outside wheels, and vents pressure at the inner shocks. The amount of control depends on whether the driver has selected the SPORT, AUTO, or SOFT button.
• **Anti-dive Control**—During braking, more air is supplied to the front struts to keep the car from diving.
• **Anti-squat Control**—The opposite happens during acceleration. More air is supplied to the rear shocks to keep the car from squatting.
• **Pitching and Bouncing Control**—The ECU takes the highs and lows out of bad roads by rapidly and alternately switching the air supply and shock damping. The ECU knows the roads are bad by measuring the amount and *frequency* of height sensor movement.



The front control valve solenoid trio is located down low, on the right front frame member, and controls air to the front strut air bags. It is located near the drier and responds to messages from the ECU. It regulates changes for HIGH/LOW or HARD/SOFT changes in the suspension.

Fine Tuning

This ride system has many programmed responses to different driving conditions. Too many, in fact, for us to list them all. But one good example of the delicate controls built into the system has to do with the way air is supplied and discharged to the shocks during cornering.

As we mentioned earlier, the front and rear shocks at the outside of the turn receive additional air pressure. The shocks away from the turn vent pressure. This combination keeps the car level during cornering.

If sustained hard cornering is sensed by the system, it closes the plumbing between the inner and outer shocks. This stabilizes air control and helps keep the body more level. Roll stiffness stays high.

As the car comes out of the turn, the system gradually evens the pressures between inner and outer shocks, allowing the vehicle to settle gradually for straight ahead driving.

In addition to air control, the ECU has programmed maps that also adjust damping to assist the air shocks.

The rear control valve solenoid trio is found in the right rear quarter panel near the electronic control unit. If we include the flow control and front control valve solenoids, we have a total of nine solenoids, although front and rear valves can only respond with an amount of air provided by flow control.

Driver Programming

The driver can also fine tune the system within certain limits. Let's say you're driving along in the AUTO-SOFT mode. If you touch the AUTO mode switch again, you can upgrade to AUTO-MEDIUM damping. To return to AUTO-SOFT, simply press the AUTO button again.

Since the AUTO mode uses a speedometer signal to automatically change from SOFT to MEDIUM damping at higher speeds, the driver can also select the speed at which this change occurs. It's a little like setting a cruise control.

The default value in the computer changes from AUTO-SOFT to AUTO-MEDIUM at 62 MPH. If the driver wants to change the speed at which this change occurs, he can keep the AUTO button depressed for a couple of seconds while driving at the desired speed (between 31 and 93 MPH).

That speed will be stored in the computer's permanent memory until the battery is disconnected for some reason, or the driver chooses to change it again. If the battery is disconnected for any reason, the base, or default value of 62 MPH will be used by the ECU.

—By Ralph Birnbaum