

NSX**DRIVETRAIN****ENGINE**
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The design targets for the engine that was to power the Acura NSX were light weight, high power output per liter, high revving capability, smoothness and instantaneous throttle response. Equally important was excellent fuel efficiency in order that the car avoid the U.S. gas guzzler tax.

A number of different engine configurations were considered but the optimum choice was a normally aspirated V6. Turbocharging or supercharging was dismissed because of the inherent boost lag which adversely effects instant throttle response. Compound turbos and superchargers were also discarded because they added a layer of complexity that the project team felt was not part of the NSX's portfolio. They wanted to keep the NSX as pure and as simple as they could. But could a normally aspirated V6 be made to produce very high power levels and still yield the durability, reliability, and smoothness for which Honda engines have been famous? The answer is obviously yes, but to get there, the engineers had to tap every resource at their disposal and practically re-invent valvetrain technology. The approach they took in developing the engine was fundamental. They felt that by optimizing basic engine technology and coming up with some fresh thinking, all the targets were achievable. In its final state of tune, the engine has among the highest power per liter output of any normally aspirated engine.

NSX**DRIVETRAIN****OVERVIEW**
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The result is an all-aluminum 3.0-liter (2977 cc), dual overhead cam, four-valve per cylinder, V6 engine which produces 270 hp at 7100 rpm when mated to the manual transmission, and 252 hp at 6600 rpm when mated to the automatic transmission. The torque rating is 210 lbs.-ft. at 5300 rpm for both manual and automatic transmissions. The redline for the manual is 8000 rpm while the automatic is 7500 rpm. Fuel cutoff is 8300 rpm for the manual and 7800 rpm for the automatic. The engine has a bore and stroke of 90 x 78 mm. The compression ratio is 10.2:1.

An exclusive Variable Valve Timing and Lift Electronic Control System (VTEC) has been developed which optimizes volumetric efficiency at both high and low engine speeds.

ENGINE BLOCK, CYLINDER HEADS, CRANKSHAFT
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To achieve both light weight and durability, the 90 Deg.-V engine block is made of aluminum alloy with cast-in steel cylinder liners. The bore pitch is 100 mm and the deck height 221.5 mm. The crankshaft is a fully counterweighted forged steel unit. The diameter of the crankpins is 50 mm and the main journal diameter is 64 mm.

The cylinder heads are low pressure cast aluminum with a different alloy than the block. This alloy was specially formulated to reduce the possibility of stress cracks. The combustion chamber is a pentroof design with generous squish area to enhance combustion efficiency. The spark plug is centrally located for correct flame propagation and features a platinum tip for improved durability and longer service life. This tip also has a special raised design to improve plug performance and enhance reliability.

NSX**DRIVETRAIN****PISTONS**
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The pistons are made of a specially formulated aluminum alloy. A molybdenum coating is applied on the piston skirts to help reduce friction and improve efficiency and power. The piston ring thicknesses are 1.2 for the top and middle ring, and 2.8 mm for the oil control ring. These thin but strong rings have been optimized to reduce friction and are very light to reduce ring flutter.

TITANIUM CONNECTING RODS
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The connecting rods are made of a specially patented titanium alloy. While titanium rods are common in Formula One and other race engines, this is the first application of titanium in a production car. The benefits of lightweight reciprocating parts like connecting rods and pistons, are many and already well-known. Lighter but very strong parts produce less parasitic power loss thereby making the engine more efficient, improving throttle response, and allowing for sustained high rpm operation without any loss in durability. Compared to a steel rod for the same engine, these titanium rods weigh 190 grams less but are significantly stronger. They can withstand 65 kg./sq. mm of stress along the longitudinal axis compared to 50 kg./sq. mm for steel. A chrome nitrite surface treatment on the large end helps to minimize wear.

VTEC

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Without question, the Variable Valve Timing and Lift Electronic Control System (VTEC) is a breakthrough in engine technology. It convincingly solves the age-old trade-offs between low end torque and high end power. With VTEC, there's no need to compromise between one and the other.

The heart of the VTEC system is a unique camshaft and rocker arm system. VTEC is installed on both intake and exhaust sides but for purposes of clarity, we'll restrict the discussion on its operation and benefits to the intake side.

For each cylinder's set of two intake valves there are three corresponding lobes on the camshaft. The two outboard lobes each have a profile suited for low engine speed operation. Each of these two lobes have a different lift profile to induce a swirl for more complete combustion. One has a total lift of 8.7 mm and the other is 8.3 mm. These two lobes act on rocker arms which in turn act on the intake valves in a conventional manner. The third, or center cam lobe, has a dramatically different profile designed for longer duration and higher lift. Lift on this lobe is 10.2 mm. This lobe profile is designed to optimize breathing and horsepower production at high engine speeds.

This high lift lobe acts on the center rocker arm, and this arm in turn acts on a lost motion spring. The spring is merely there to reduce arm play while VTEC is disengaged.

Besides the center, high lift lobe, what makes this valvetrain different are two pistons and a stopper pin installed at right angles in the rocker arms. Under high load or high speed operation, the VTEC computer sends a signal to a spool valve which in turn delivers engine oil to the pistons in the rocker arms. Oil pressure causes the pistons to

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slide inward, locking all three rocker arms together. It takes 4.5 kg./sq. cm oil pressure to overcome the spring pressure and engage VTEC. Once locked together, the rocker arms are then forced into following the profile of the high lift center cam lobe. At this point the intake valves have the higher 10.2 mm lift and longer duration, a condition which promotes better engine breathing and produces a noticeable increase in power. The cross-over from low lift to high lift occurs in 0.1 sec. and is virtually transparent to the driver.

The cam lobe surface material is nickel chrome molybdenum and receives heat treatment, chilling and an oxidation process to ensure proper surface hardening. The high rpm, center lobe has an additional remelting process treatment to further enhance durability.

The two exhaust valves have lift of 7.7 and 7.4 mm in normal operation and go up to 9.0 mm when VTEC is engaged. The timing and duration is also altered when VTEC is engaged. When mated to the automatic transmission, the engine has a different set of lift and duration specifications to tailor the power and torque curve to this transmission.

VTEC VALVE TIMING FOR ENGINE WITH 5-SPEED

	INTAKE	EXHAUST
VTEC DISENGAGED	VALVE 1	VALVE 1
OPENS	7.5 Deg. ATDC	30 Deg. BBDC
CLOSES	25 Deg. ABDC	7.5 Deg. BTDC
LIFT	8.7 mm	7.7 mm
	VALVE 2	VALVE 2
OPENS	12.5 Deg. ATDC	25 Deg. BBDC
CLOSES	25 Deg. ABDC	7.5 Deg. BTDC
LIFT	8.3 mm	7.4 mm
VTEC ENGAGED	BOTH INTAKE VALVES	BOTH EXHAUST VALVES
OPENS	5 Deg. BTDC	40 Deg. BBDC
CLOSES	45 Deg. ABDC	5 Deg. ATDC
LIFT	10.2 mm	9.0 mm

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VTEC uses a dedicated CPU which monitors a number of engine parameters and activates the system only when certain thresholds are met. It's designed to engage between 5800 and 6000 rpm depending on conditions and will not engage under a no load situation. As installed and calibrated in the NSX engine, VTEC adds 20 hp and also provides more torque and a broader torque curve.

The cam drive belt is a lightweight, high strength synthetic unit made of woven cloth, rubber and glass fiber with an adhesive between the layers. The belt teeth have a special weave for added strength. To minimize vibration, the cam pulleys have been inertia mass tuned.

VTEC is covered by numerous patents and is exclusive to Honda.

VALVES

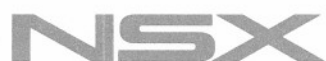
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To improve durability and reduce airflow restriction, the valves are made of a special high strength tool steel allowing the valve stem size to be 5.5 mm. Valve adjustment is by conventional screw arrangement because it was found that hydraulic tappets produce too much friction and inhibit high rpm operation. The engine has rev limiter settings of 8000 and 7500 rpm (manual and automatic respectively). The diameter of the intake valves is 35 mm and the exhaust valves are 30 mm in diameter. The intake port diameter is 33 x 55 mm while the exhaust port diameter is 33 x 48 mm.

VARIABLE VOLUME INDUCTION SYSTEM
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In addition to variable valve timing, the NSX engine also uses a variable volume induction system. This system uses a separate magnesium plenum, located beneath the main intake manifold. This second plenum is separated from the primary manifold by six butterfly valves. These valves open at approximately 4800 rpm and are activated by manifold vacuum. The bores which connect the primary and secondary manifold are 64 mm in diameter. The volume of the primary intake plenum is 4.6 liters while that of the secondary plenum is 2.4 liters.

When the butterfly valves are closed, the main intake manifold separates the front and rear bank of cylinders. Under this condition, the chamber creates a resonance effect which improves low and midrange torque. When the valves open, one large chamber is created and ties both banks of cylinders to the same intake plenum. This reduces the resonance effect but creates an inertia ram tuning effect which optimizes high end breathing and provides more horsepower. This system was designed to work in concert with VTEC to improve low end torque. The diameter of the intake runners is 46 mm and the total length of each runner is 325 mm.



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PROGRAMMED FUEL INJECTION (PGM-FI)

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Programmed sequential port fuel injection ensures that each cylinder receives only the precise amount of fuel necessary for the given load and speed conditions. This system, although similar in concept to the system found in the Legend, has been specially tailored to the unique capabilities of the Variable Volume Induction system and the VTEC system.

The fuel injection system is controlled by an eight-bit microprocessor which monitors several sensors including: throttle angle, crankshaft angle, coolant temperature, intake air temperature, manifold air pressure, ambient air pressure and exhaust gas oxygen content. The system meters fuel at the correct stoichiometric ratio under all operating conditions to provide maximum performance and fuel efficiency.

To ensure adequate fuel delivery even at elevated engine speeds the injection system is rated at 120 liters per hour at maximum operating range and 60 liters per hour at normal operating speeds. Fuel pressure is 3.5 kg./sq. cm $\pm$ 0.05.

AIR INTAKE

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Air for the engine is delivered by means of an intake duct on the driver's side, rear quarter panel. To reduce the roar and intake boom commonly associated with this type of intake system, a tuned duct is used to route the intake charge to the manifold cancelling intake noise. The intake duct on the right side of the vehicle is used to cool the engine compartment while a fan directs ambient air to the alternator to keep it cool and maintain optimum charging efficiency. The diameter of this fan is 155 mm.

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The air cleaner element has been specially designed to minimize restriction of air flow into the engine.

The volume of the air cleaner housing is 9.7 liters and the surface area of the air cleaner element is 3940 sq. cm. The intake air snorkel is 90 x 320 mm.

DIRECT IGNITION SYSTEM
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To ensure a hot, stable spark at high rpm operation, the single coil ignition system has been superseded by a coil mounted atop each spark plug, a design similar to that used in the Honda Formula One car. This system ensures a stable spark up to 8000 rpm. A sensor mounted behind one of the camshafts is the trigger for spark plug ignition. Also, specially designed platinum-tipped spark plugs help increase ignition energy and enhance plug life.

OIL SYSTEM
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To supply the necessary amount of oil at high engine speeds, a new high-volume recirculating oil pump has been developed. Oil pan scavenging has been improved by use of a oil baffle in the pan. The NSX can maintain a sustained 0.8 g lateral load without oil starvation and can spike up to 1.2 g without starving for oil. The flow capacity of this pump is 68 liters per minute at 6000 rpm and operates at 6.8 kg./sq cm pressure. Oil pressure is monitored by a gauge in the instrument panel. The recommended engine oil is 10W-30SG. To maintain appropriate oil temperatures, a liquid cooled oil cooler has been designed. It's located at the base of the oil filter mounting boss. The oil pan capacity is 4.3 liters while total engine oil capacity is 6.3 liters.

COOLING SYSTEM

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The goal of the cooling system was to provide maximum cooling efficiency at high speeds, medium speeds and at idle even in the harshest climate. The radiator core is made of aluminum and the header tank of a special high-strength nylon. The flow capacity of the belt-driven water pump is 150 liters per minute at 6000 rpm. The fins of the radiator are 2.5 mm thick and they have a 2 Deg. pitch for maximum cooling efficiency. The radiator fan is 320 mm in diameter. The entire cooling system is rated at 47,100 K Cal/hour.

The radiator fins, tubes and pipes carrying coolant from the radiator to the engine are all made from aluminum.

Development work on the cooling system was conducted in the Australian desert in more than 100 Deg. F. ambient temperature. Testing was conducted with the air conditioning unit operating at all times. Some of the targets included repeated runs at 140 mph on level ground and up a 5.6% slope, and sudden stops from high speeds followed by an extended hot soak at idle.

The intake duct on the right side of the vehicle is used to cool the engine compartment while a fan directs ambient air to the alternator to keep it cool and maintain optimum charging efficiency. The diameter of this fan is 155 mm.

EXHAUST SYSTEM

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The dual exhaust system has been developed to produce equally low exhaust back-pressure on both sides. The exhaust headers are a unique cast iron composition while the rest of the system is stainless steel for improved corrosion protection. The system uses dual catalytic converters with dimensions of 81.3 x 144.8 x 95mm. The volume of each catalytic converter is 0.95 liter.

The exhaust note of an exotic is an important part of its personality. In a sense, it's the voice with which it addresses the world. In tuning the exhaust note the engineers wanted a sound that reflected the car's high level of technical competence and one that clearly set it apart as the new-generation exotic. The sound had to be aggressive and powerful but above all it had to be a clean high-register note — more evocative of a Formula One car than a large displacement street engine which typically has a low, guttural sound. At steady speed, the system is designed to be un-intrusive. But it makes its presence known under acceleration.

MANUAL TRANSMISSION

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The goals for the manual transmission were to create a transaxle package matched to the high power and torque of the NSX engine and to provide the driver with a short-throw gear change, smooth engagement, and a light, progressive clutch.

The transaxle features a double-cone synchronizer in second gear and a synchronized reverse gear as well. Also, gear noise in all forward gears has been reduced and the typical whine found in many reverse gears has been eliminated by a combination of refinements including design of the gear teeth and adjusting backlash.

These goals were achieved by developing a number of refinements. These design details have produced significant improvements and contributed substantially to the feel and precision of the manual transmission. The shift change load is significantly lighter than the leading competitors. The shift throw is 40 mm, which compares well to the 60 to 70 mm of most exotics. The shifter uses a large diameter cable design to the transaxle which provides excellent shift feel and precision.

Additionally, oil agitation and foaming has been reduced significantly by developing a forced lubrication system driven by a trochoid oil pump. The pump is located in the transmission and is powered by a spur gear.

Gear ratios in the manual transmission are below;

1st	3.071:1
2nd	1.727:1
3rd	1.230:1
4th	0.967:1
5th	0.771:1
Reverse	3.186:1
Final drive	4.062:1.

The overall weight of the manual transmission is 76.7 kg. including the clutch.

TWIN DISC CLUTCH

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As the major interface component between the engine and the rest of the drivetrain, the NSX clutch design received considerable attention. The first design priority was that it be able to withstand the power and torque of the engine. Also, it had to have a short stroke, engage smoothly, offer low effort in order that it not become tiring in city driving and it had to be light and compact.

To meet all these requirements, the engineers designed a hydraulically activated, self-adjusting, pull-type clutch with a twin disc configuration. The twin disc design is a smaller diameter than a single disc clutch and reduces the rotational mass of the unit. The smaller diameter allows the engine to rev more quickly. For enhanced durability, the second pressure plate is ventilated to dissipate heat build-up. An aluminum pressure plate housing is used to reduce overall weight.

This unit requires only a 13 kg pedal effort, despite the high horsepower and torque of the NSX engine. Competitors have pedal efforts in the range of 14 to 19 kg. The stroke is only 130 mm. The clutch pedal stroke measured on most of the competitors in this class ranges between 135 and 155 mm. This unit also offers a linear and very progressive take-up to provide smooth clutch engagement and prevent the jarring all-in or all-out clutch engagement typical in many high horsepower cars. This is accomplished by having the first plate engage and then the second in a progressive manner.

AUTOMATIC TRANSMISSION

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For drivers who choose the 4-speed automatic transmission, the engineers wanted to provide them with the same sporty feel as the manual. Under maximum acceleration, this 4-speed transmission holds each gear close to the redline before upshifting. This transmission allows the driver to manually select each gear. A solenoid is used in place of a throttle cable to activate the kickdown. And, to enhance smoothness between upshifts and downshifts, an ignition retard control system is used to momentarily reduce engine output.

Under cold, fast idle conditions with the transmission in "Drive", the transmission automatically engages 2nd gear to reduce forward creep, but automatically selects 1st gear when moving off. The automatic is also equipped with a programmed lockup torque converter to improve fuel economy and reduce slippage. Lock-up is available in third and fourth gears and, unlike other automatic transmissions, it occurs in four increments, rather than one abrupt transition, to provide smooth operation. The transmission is unique in that it maintains lock-up while the car is decelerating. To ensure maximum reliability 2nd, 3rd, and top gear are made of a high strength material and a transmission fluid cooler is fitted as an integral part of the torque converter case.

The gear ratios are:

1st	2.611:1
2nd	1.551:1
3rd	1.025:1
4th	0.684:1
Reverse	1.909:1
Final drive	4.428:1

The overall weight of the automatic transmission is 104 Kg.

TORQUE CONTROL DIFFERENTIAL

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The torque control differential is designed to help maintain traction when driving over split friction surface conditions and maintain vehicle stability at speed in crosswinds. It employs a multi-plate clutch and planetary gearset design. Like many conventional LSD (Limited Slip Differential) systems, this unit resists the rotational difference between the rear wheels and attempts to maintain the same rate of rotation at both wheels. But unlike most units, the amount of additional torque resisting the rotational difference is limited to 16 kg-m. This reduces understeer by not trying to keep the car from going towards the direction in which it is being steered. In a cornering situation, too much torque transfer to the inside rear wheel tends to oppose the turning moment from the front wheels, thereby increasing understeer.

If the NSX should be disturbed from its intended direction in a crosswind, the differential will detect the rotational difference between the two rear wheels and transfer torque to the slower rotating wheel. This has the effect of helping to keep the car on the desired path.

Compared to both conventional open differentials or limited slip differentials, straight line tracking is improved, especially in cross winds. On a split friction road surface, the acceleration time was reduced compared to a conventional open differential.

FLAT ROLLER CONSTANT VELOCITY JOINTS

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To manage the high power output, reduce vibration, increase the service life of the driveshaft, and minimize harshness a new, flat roller CV joint was developed for the NSX. This new design allows for a larger amount of lateral slide motion (57 mm vs. 22 mm compared to the average in this class) which reduces the possibility of binding and excessive vibration under maximum vertical loads. It's also smaller in overall height (92 mm vs. 108 mm for the competition).

TRACTION CONTROL SYSTEM (TCS)

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One goal of the Traction Control System (TCS) is to minimize rear wheelspin on slippery or uneven road conditions. Yet unlike some other traction control systems, this Honda R&D development was created as a high performance system that functions over a wide range of speeds and cornering situations rather than simply a low-speed traction enhancing device. The key to this is creating a system that could differentiate between low speed, poor traction conditions and high speed cornering and modulate the wheelspin accordingly.

TCS uses the wheel speed sensors of the Anti-Lock Braking system to detect the rotational differences between the two front wheels. Using this information, plus vehicle speed and changes in steering wheel angle from a steering wheel angle sensor, it estimates the yaw rate and the cornering force (or lack of it) acting on the car. It compares this information to a map stored in the TCS central processing unit and determines whether or not the car is cornering hard on dry pavement or is tending to spin its wheel(s) on a slippery surface.

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If, the computer determines that the surface is slippery, CPU signals are sent to the fuel injection system and decrease the amount of fuel delivered to the engine. A signal is also sent to a step motor attached to the throttle plate which incrementally closes the throttle. This has the effect of reducing engine power, thereby reducing power to the rear wheels, and suppressing wheelspin.

The system maps are sophisticated enough that TCS can determine the difference between a road which is dry, wet or icy. As a further refinement, a vibration sensor is installed which determines if the vehicle is travelling on a rough road. In this scenario, it suppresses or allows wheelspin in accordance with the rapidly changing conditions. The elapsed time between detecting wheelspin and taking the appropriate action is 0.3 sec. The driver can elect to disengage TCS by a switch located on the instrument panel.

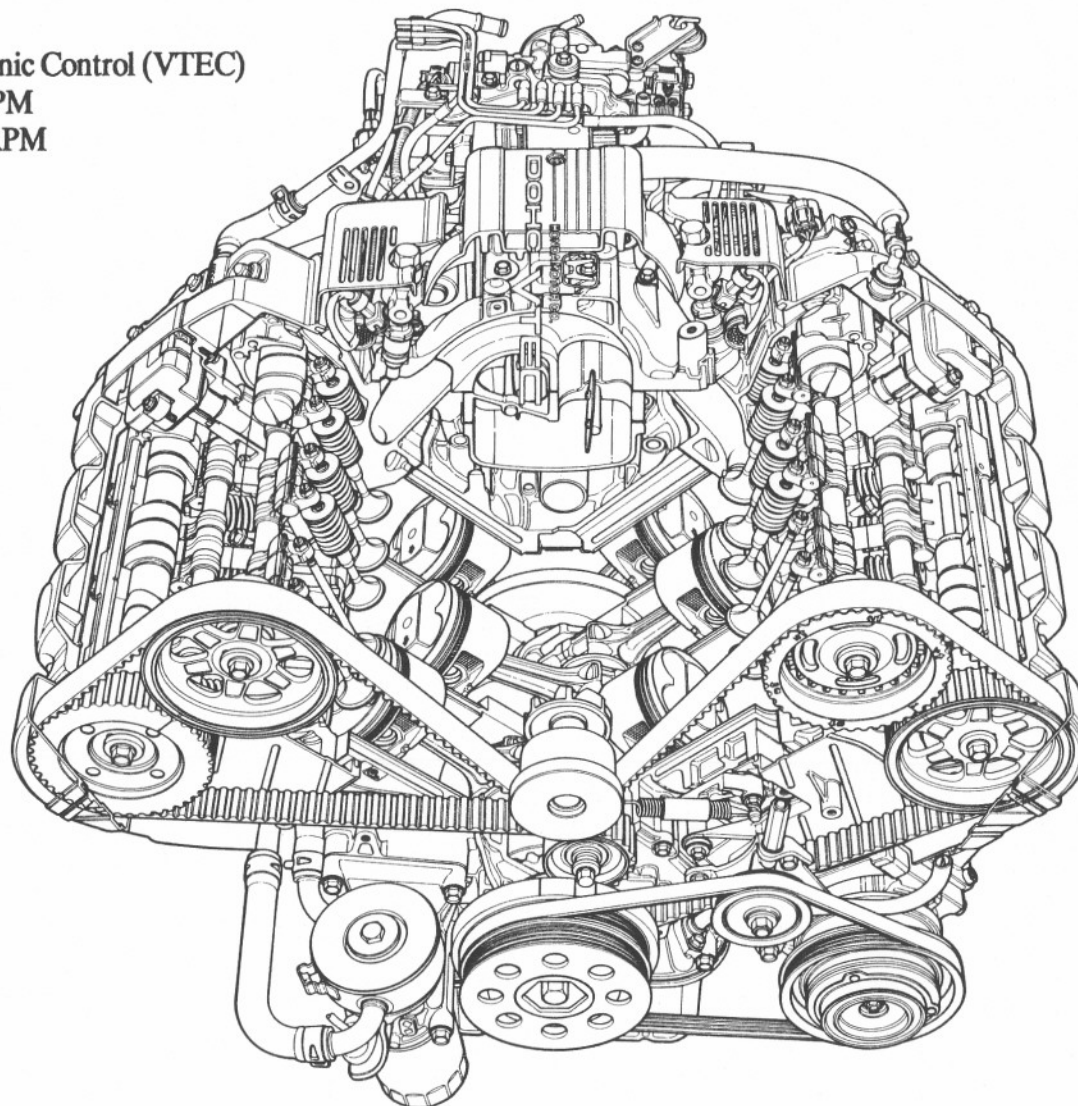
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ENGINE

3.0 Liter DOHC 24-Valve V-6 Engine
Variable Valve Timing and Lift Electronic Control (VTEC)
Maximum Horsepower: 270 @ 7100 RPM
Maximum Torque: 210 lb.- ft. @ 5300 RPM

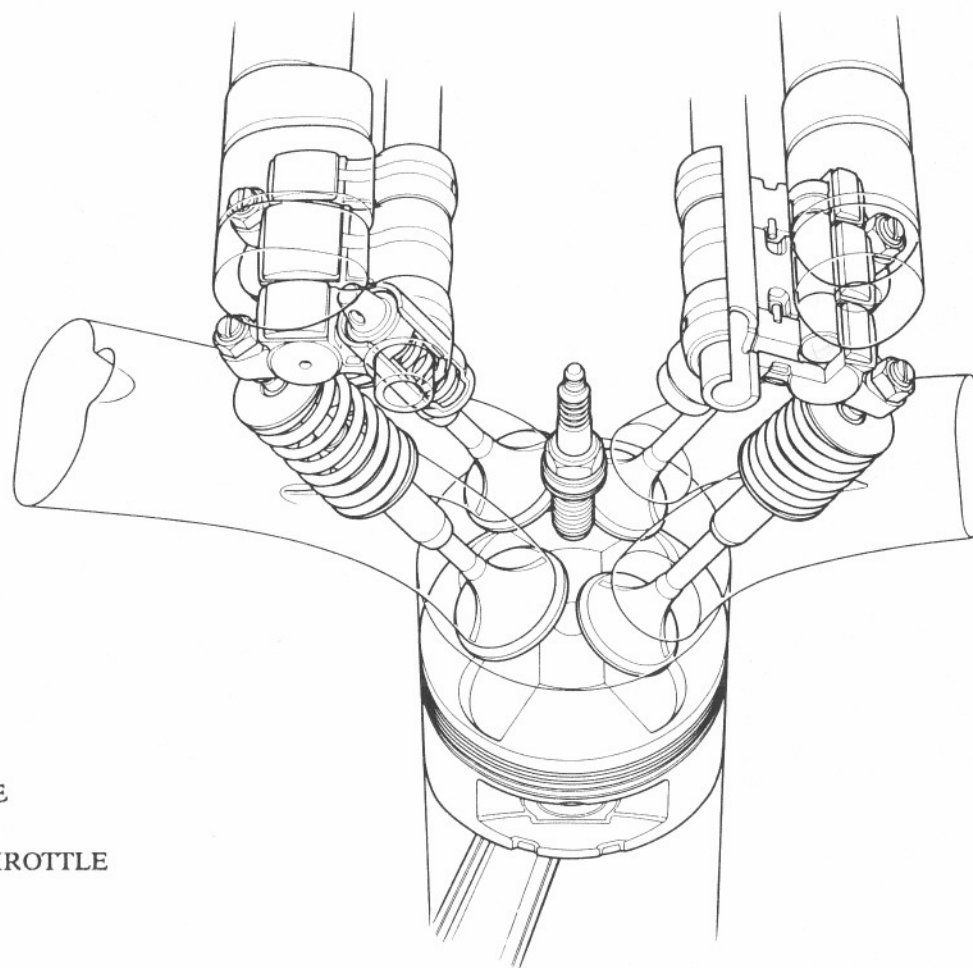
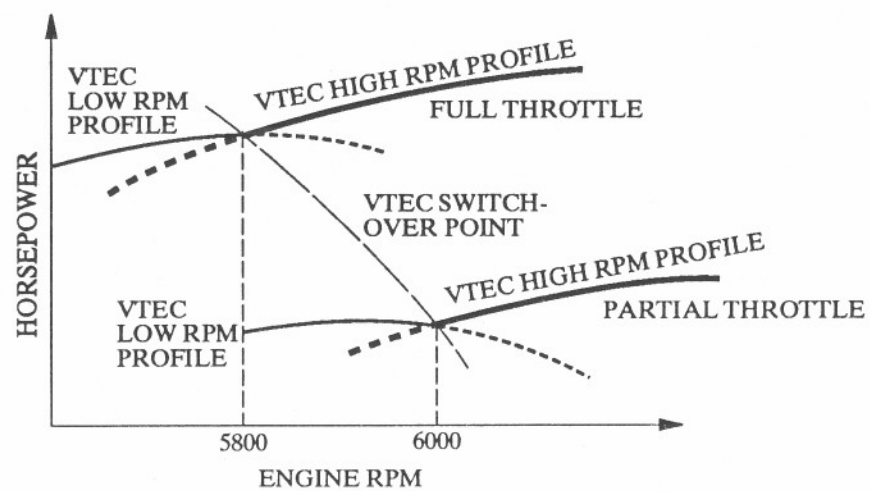


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VARIABLE VALVE TIMING AND LIFT ELECTRONIC CONTROL (VTEC)



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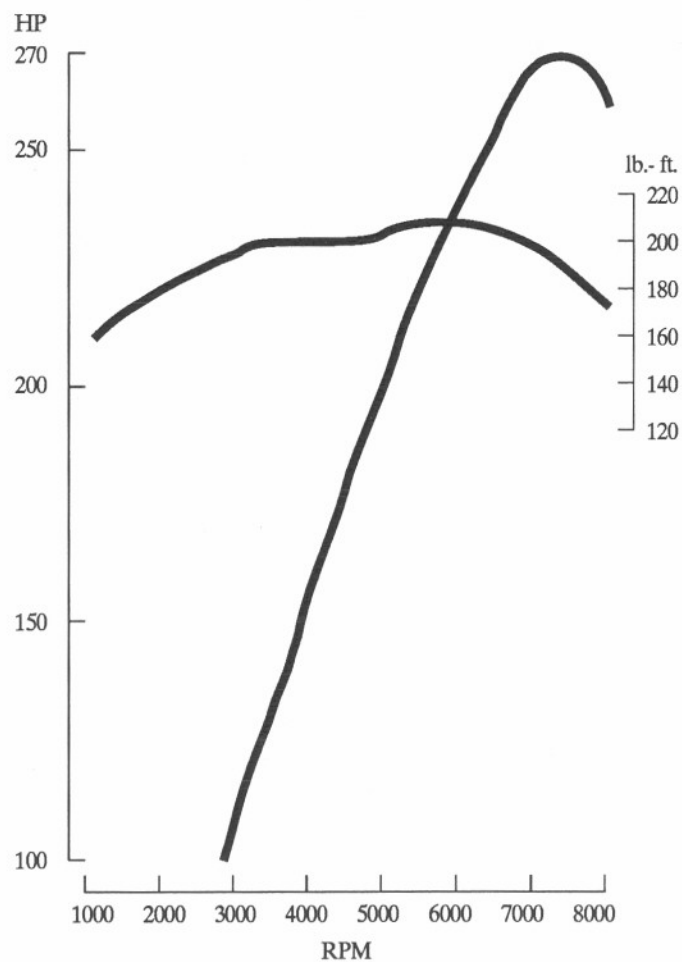
DRIVETRAIN

ENGINE PERFORMANCE CURVE

MANUAL TRANSMISSION

270 HP/7100 RPM

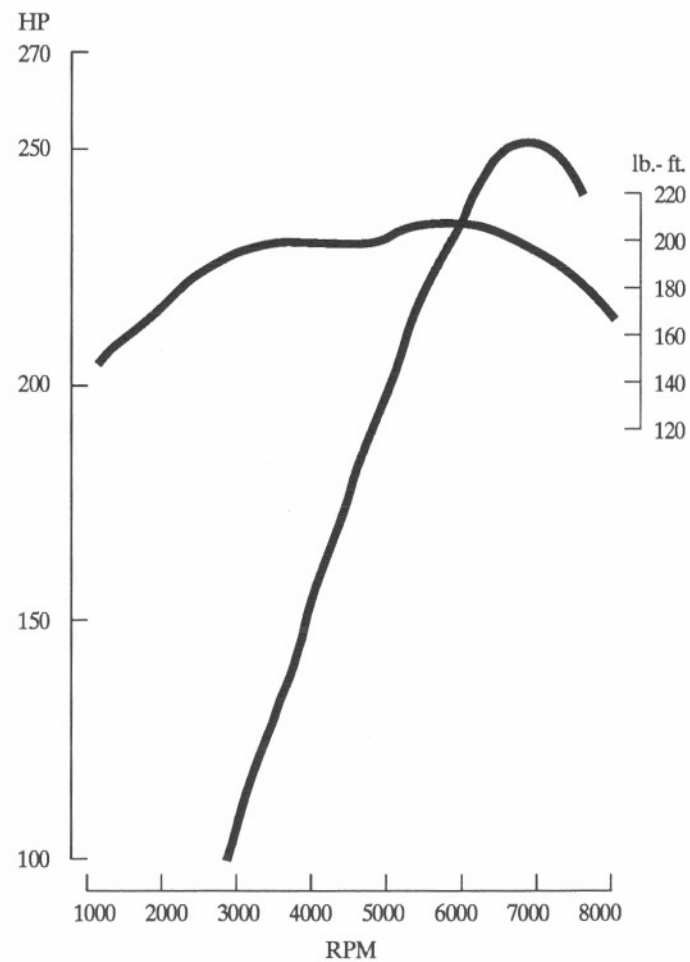
210 LB.-FT./5300 RPM



AUTOMATIC TRANSMISSION

252 HP/6600 RPM

210 LB.-FT./5300 RPM

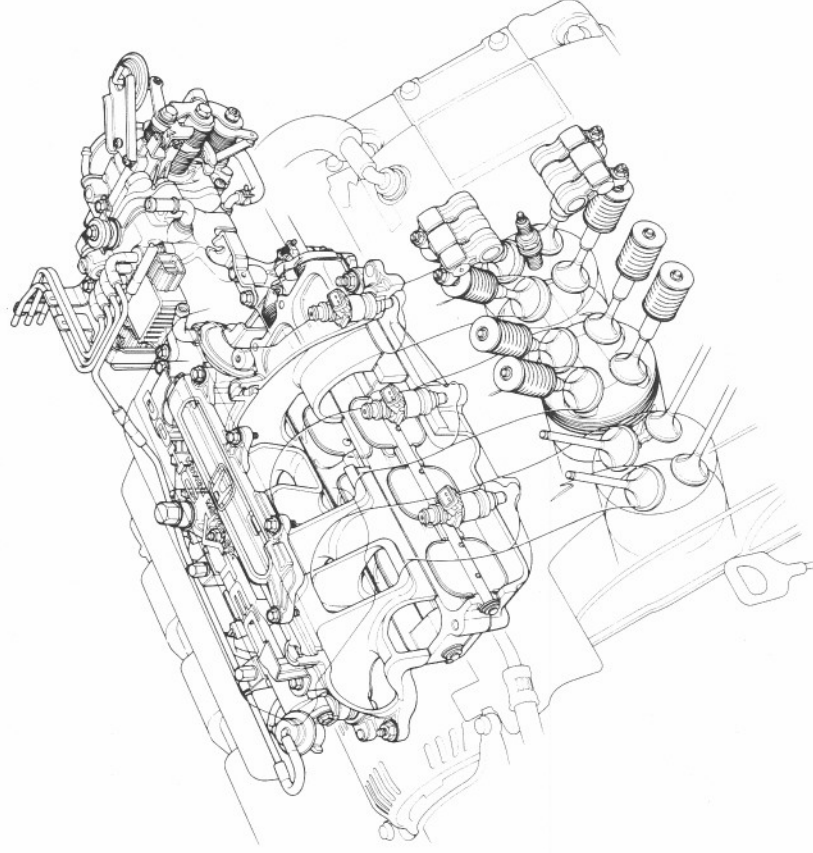


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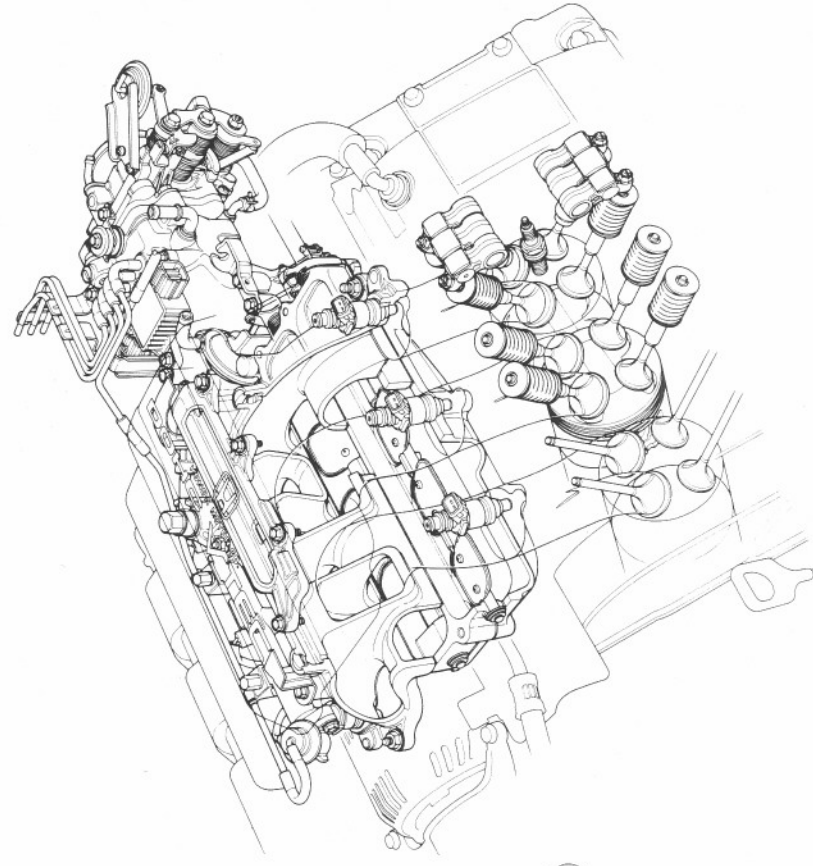
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VARIABLE VOLUME INDUCTION SYSTEM

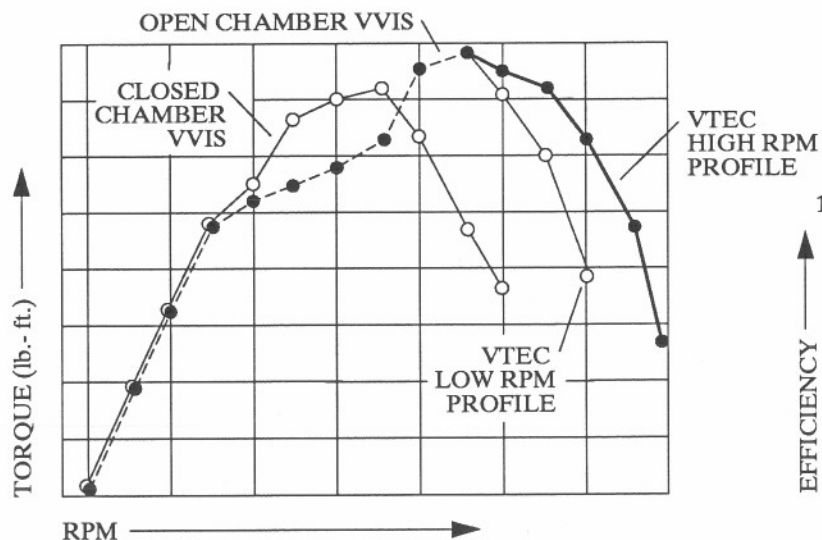


VALVES OPEN (AT APPROXIMATELY 4800 RPM)

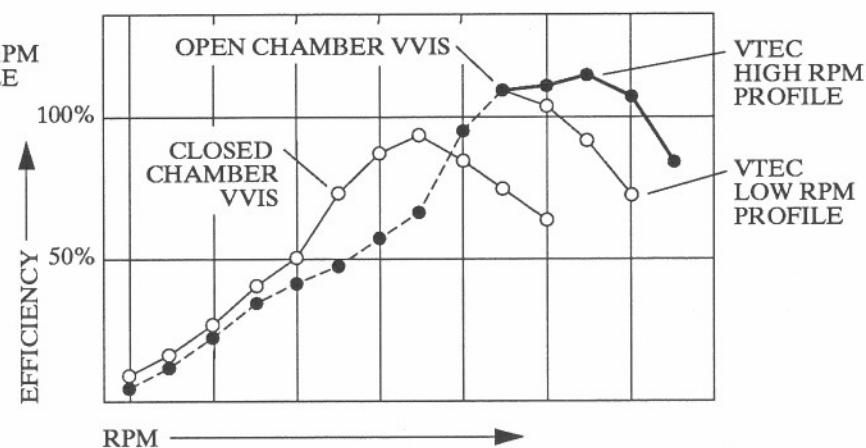


VALVES CLOSED

ENGINE PERFORMANCE CURVE IMPROVEMENT WITH VTEC/VARIABLE VOLUME INDUCTION SYSTEM (VVIS)



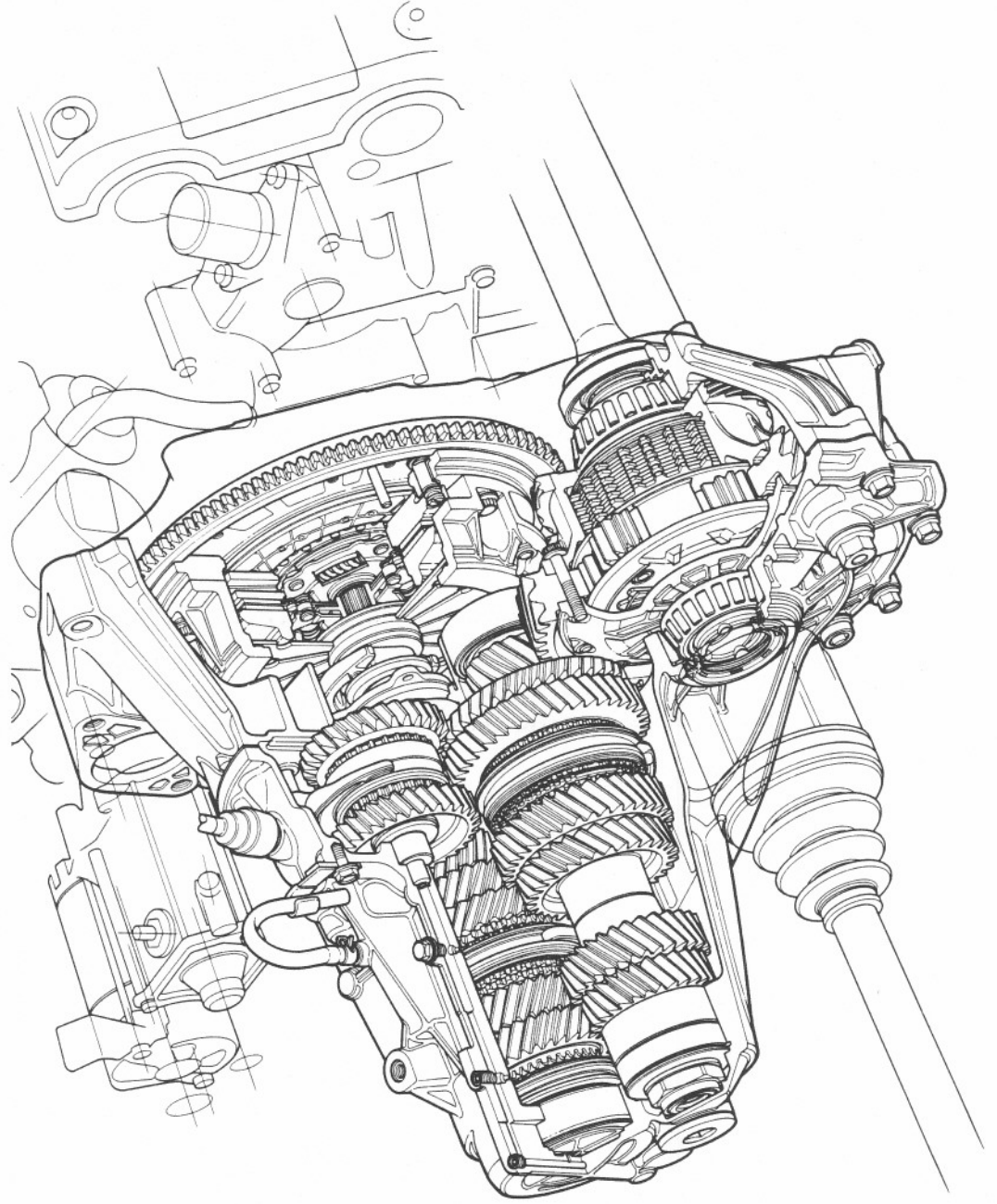
MAXIMUM TORQUE:
210 LB.- FT. @ 5300 RPM



CYLINDER CHARGING EFFICIENCY:

$$\left(\frac{\text{VOLUME OF AIR DRAWN INTO CYLINDER}}{\text{CALCULATED VOLUME OF CYLINDER}} \right)$$

5-SPEED MANUAL TRANSMISSION, DUAL DISC CLUTCH AND TORQUE CONTROL DIFFERENTIAL	
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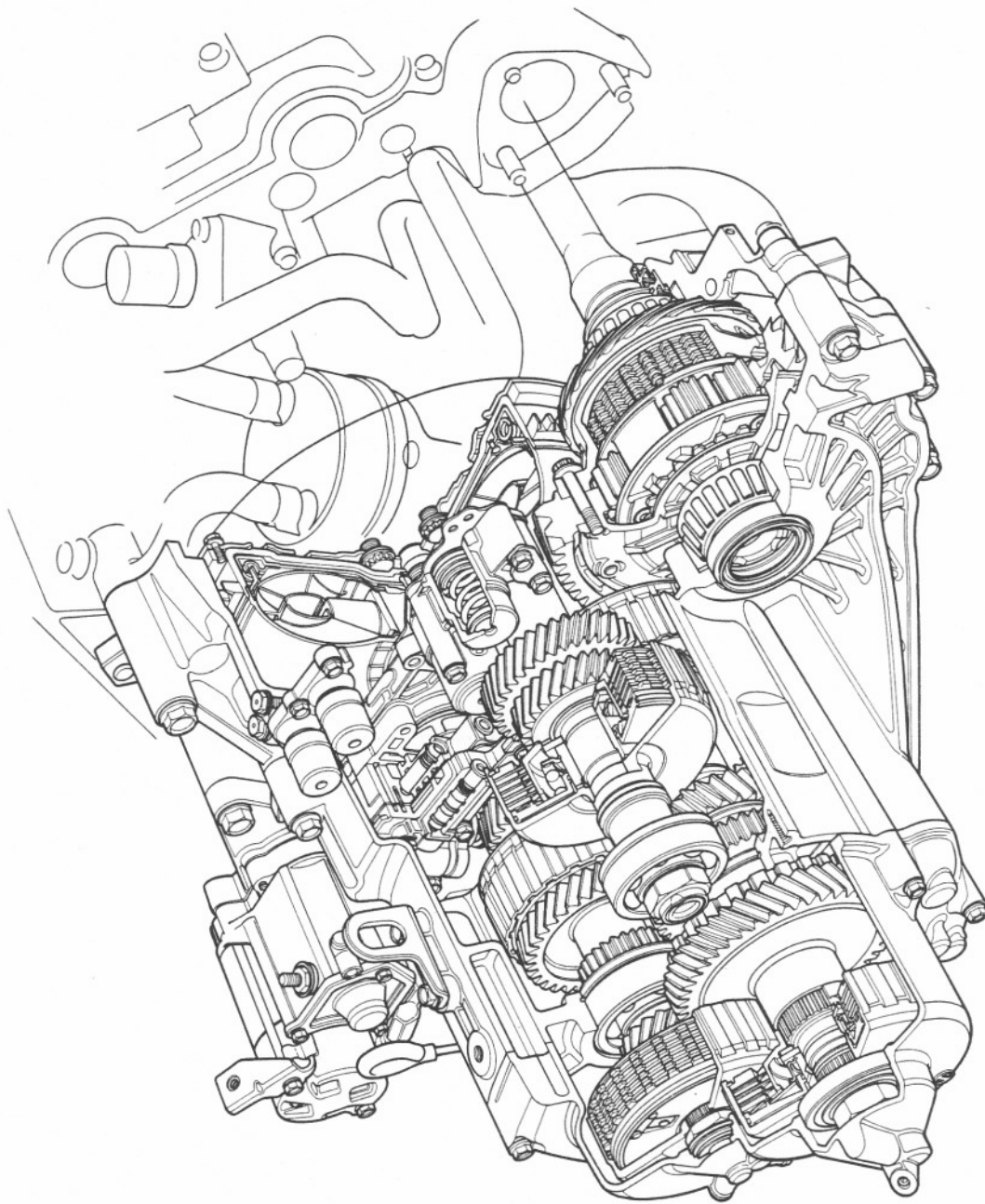


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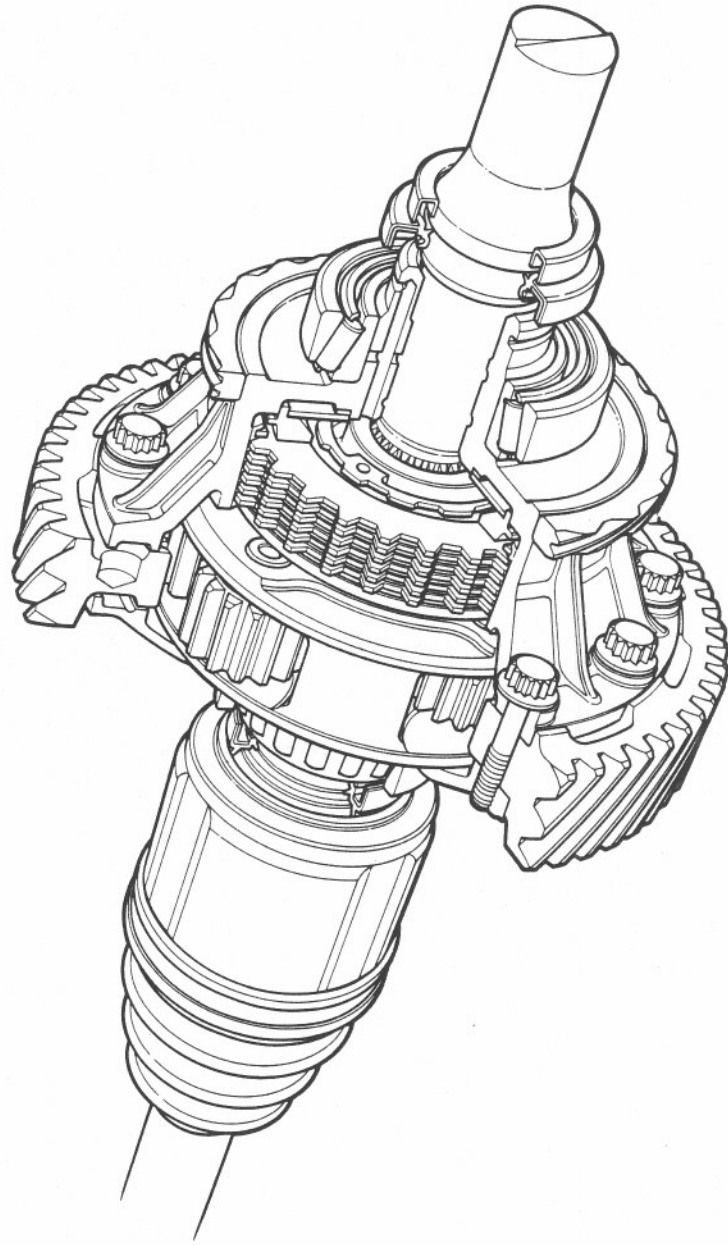
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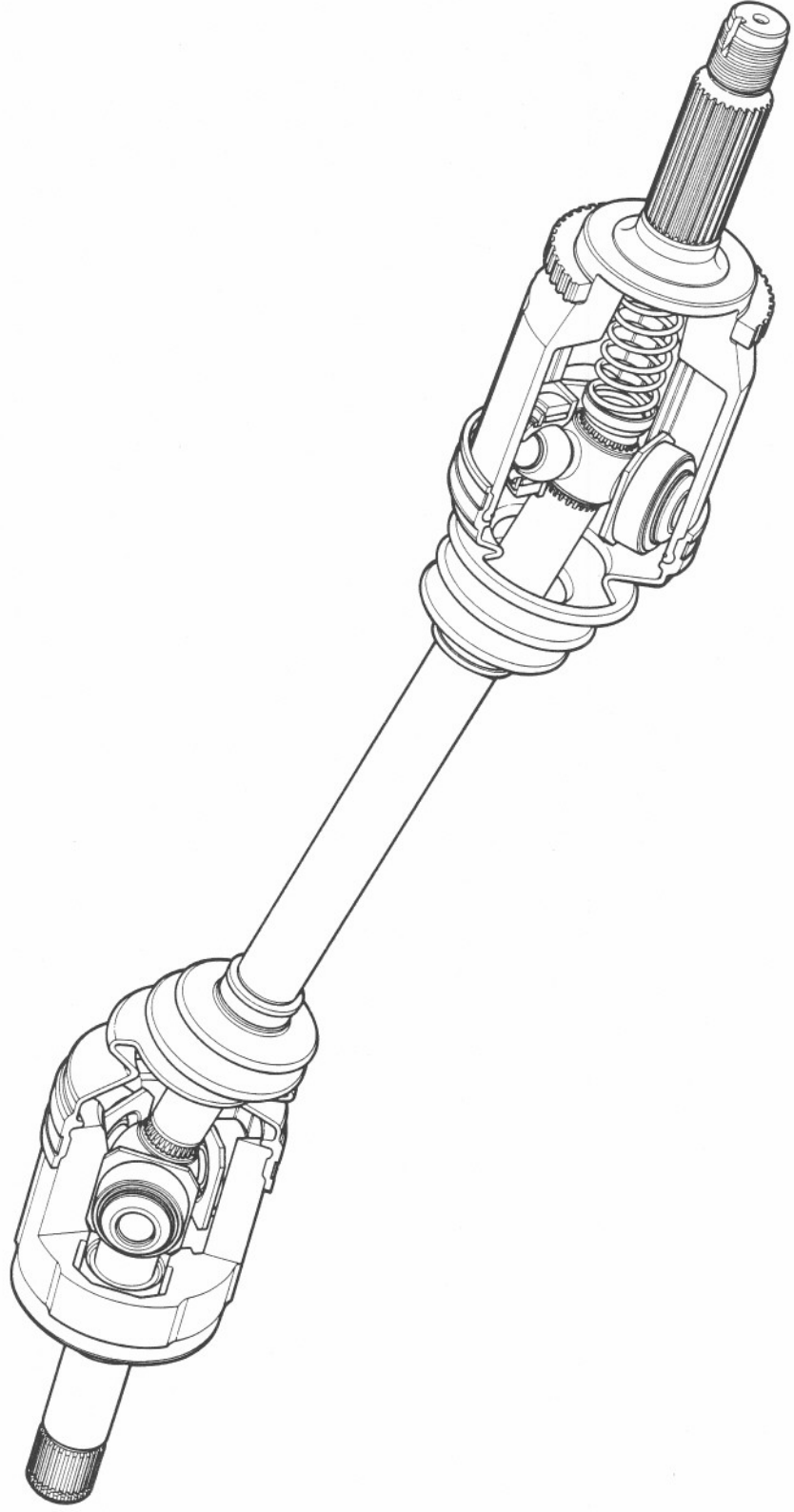
AUTOMATIC TRANSMISSION.....



TORQUE CONTROL DIFFERENTIAL.....



FLAT ROLLER CONSTANT VELOCITY JOINTS.....

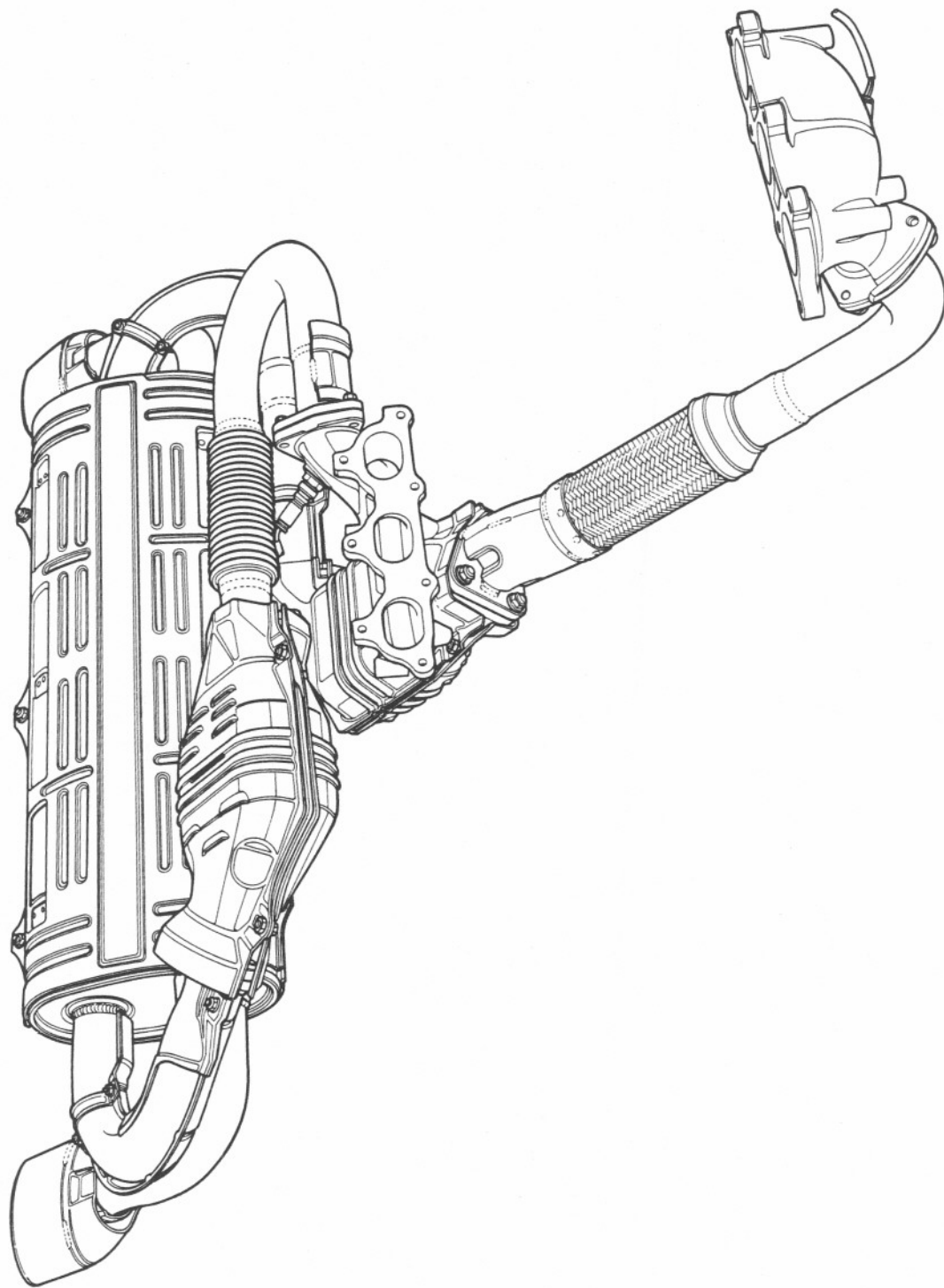


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EXHAUST SYSTEM

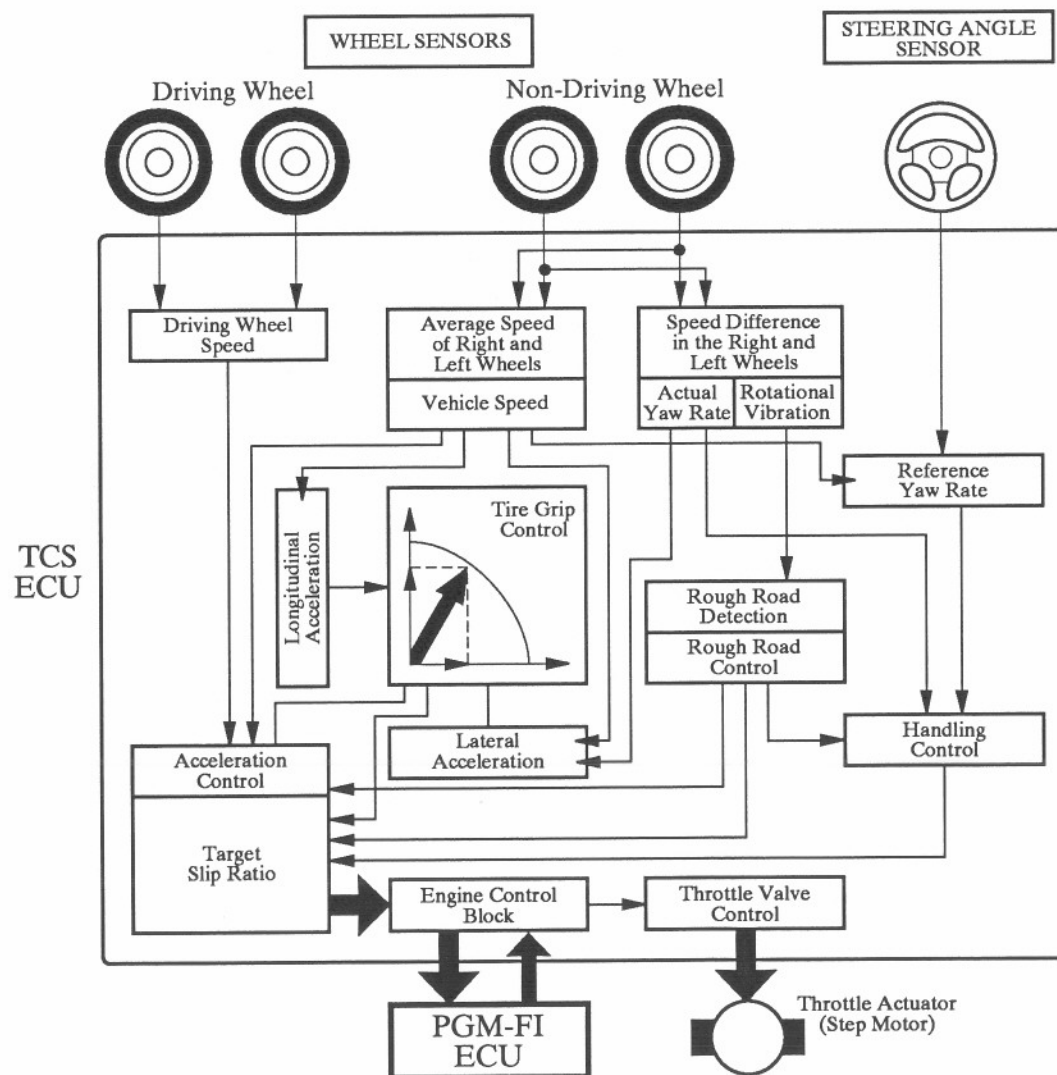
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TRACTION CONTROL SYSTEM (TCS)

Control Algorithm

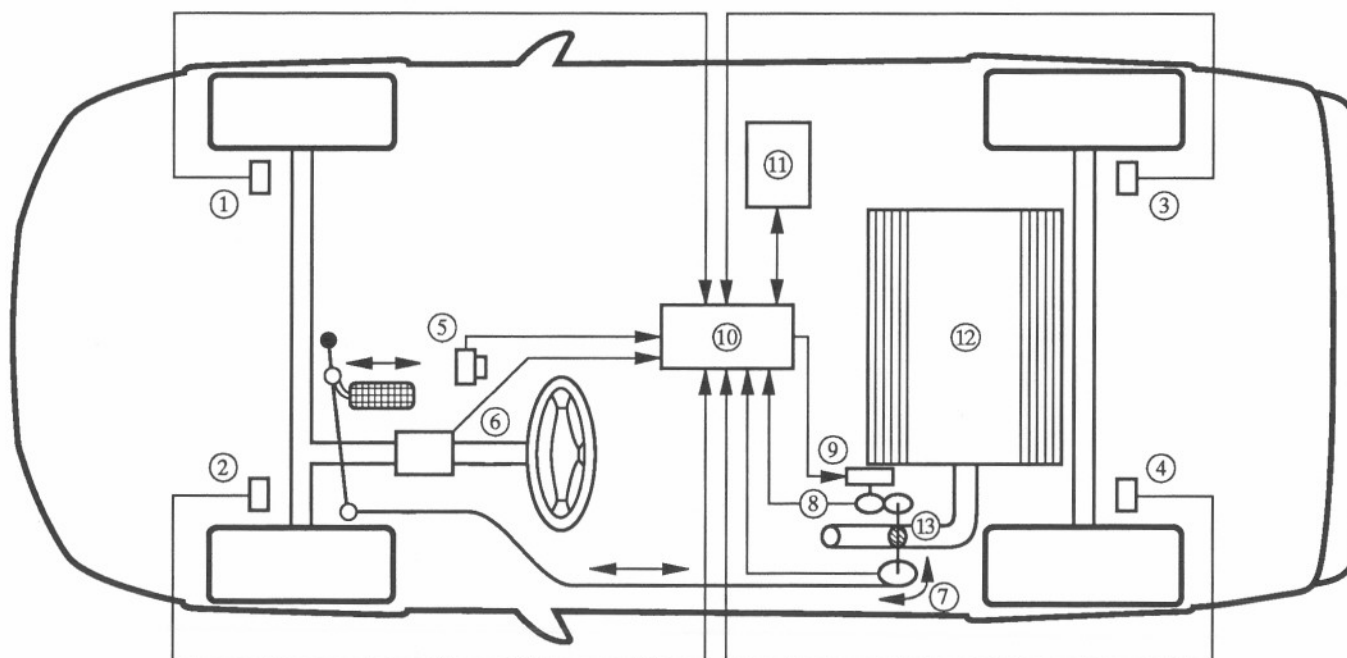


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TRACTION CONTROL SYSTEM (TCS)

Schematic Diagram



- ① WHEEL SENSOR FRONT RIGHT
- ② WHEEL SENSOR FRONT LEFT
- ③ WHEEL SENSOR REAR RIGHT
- ④ WHEEL SENSOR REAR LEFT
- ⑤ TCS ON/OFF SWITCH
- ⑥ STEERING ANGLE SENSOR
- ⑦ ACCELERATOR PEDAL ANGLE SENSOR

- ⑧ THROTTLE VALVE ANGLE SENSOR
- ⑨ STEP MOTOR
- ⑩ TCS ECU
- ⑪ PGM-FI ECU
- ⑫ V-6 DOHC VTEC ENGINE
- ⑬ THROTTLE BODY