

NSX**CHASSIS****SUSPENSION**
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The desired goals for the NSX suspension went well beyond the typical goals of high lateral adhesion, transient response and linear response to control input. The engineers wanted a suspension that allowed the driver to easily control the car right to the limit. Virtually all the exotics the engineers evaluated exhibited shortcomings in the two crucial areas of "feel" and "ease of control." They became tiresome to drive at speed for extended periods of time. They wanted the NSX to be always rewarding and never tiresome.

A major design target was reducing unsprung weight to the lowest possible values. Low unsprung weight makes it easier to control wheel motions to maintain tire contact, manage vertical loads and provide precise response to steering input. To this end every suspension component is made from an aluminum forging or casting. The suspension components in total are more than 20 kg. (44 lbs.) lighter than comparable steel components.

The basic configuration is similar to that of a Formula One car in that it employs an upper and lower control arm (or double wishbone) design with a coil-over shock absorber and anti-roll bar front and rear. The rear suspension also has an additional lateral link for greater wheel control. All the suspension arms are made of extremely rigid and durable forged aluminum. The front steering knuckles and the rear hub carriers are made from aluminum castings. The springs are straight rate with an extended rubber bump stop which acts as a progressive springing element at the limit of wheel travel.

The shock absorbers are gas filled and feature a newly designed HPV piston and bottom valve which opens progressively under vertical loads. The progressive opening of this valve produces a more favorable damping profile and more precise damping control than a conventional valve system in which the fluid control orifices are either fully opened or closed.

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The front and rear suspension components are mounted on a separate sub-frame. These subframes consist of aluminum forgings, castings, extrusions and stampings for light weight and high rigidity.

The main difference between the NSX and a Formula One suspension, of course, is that while a Formula One car makes no allowances for ride quality, good bump absorption or generous wheel travel, the suspension on the NSX had to be designed to have those properties as well.

To that end, the suspension development program was far-ranging and took place at the Tochigi Proving Grounds, the Suzuka circuit and the long Nurburgring course in Germany. In addition to the standard evaluations conducted in-house by the suspension engineers, the car was subjected to evaluation by top rank drivers such as 1988 Formula One World Champion Ayrton Senna, Indianapolis 500 winner Bobby Rahal, and Japan's Satoru Nakajima.

It's a known fact that in developing a racing car, or any high performance system, the big gains can be made fairly easily and quickly. A month of solid work, for example, can achieve 80 or 90% of the desired suspension tuning. But it can take several more months to achieve the next 5% and many more months beyond that to achieve those final few percentages which very often spell the difference between a suspension which is merely good and one that's a hands-down winner. The contributions of these drivers were invaluable in extracting those crucial percentage points.

The one thing the suspension development team didn't have to worry about was chassis rigidity. A chassis with insufficient torsional rigidity will cause unwanted movement in suspension components. This will in turn undermine even the most carefully calibrated suspension system. The NSX aluminum unit-body structure was sufficiently rigid, however, that development engineers could concentrate their efforts completely on calibrating the suspension and not in compensating for a flexible platform.

FRONT SUSPENSION

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The front suspension uses an upper and lower control arm (also known as double wishbone or double A-arm), a compliance pivot which is used as the mounting point for the forward pivots of both upper and lower control arms, an anti-roll bar and a coil over, nitrogen gas-filled shock absorber. The geometry at the front uses a large caster angle and small trail geometry to enhance straight line stability and a light steering feel.

Although light and compact, the forged aluminum control arms, both front and rear, the compliance pivot and the rest of the aluminum suspension components are extremely strong units. The design was optimized using the latest computerized stress analysis programs and the strength, durability, impact resistance and corrosion resistance targets were verified by extensive laboratory and track testing. They are equal in strength to steel units but are roughly half the weight.

As is already well-known, the number one enemy of any suspension development program is unwanted toe change under dynamic conditions. Toe change occurs when the wheels are deflected from their desired steering direction by vertical or cornering loads or braking. In a cornering situation, severe lateral loads are imparted to the wheels, the control arms and control arm bushings. In some suspension systems these loads will deflect the bushings and the control arms thereby allowing the front wheels to deflect as well. Although this deflection at the wheels is small, nonetheless it translates into sloppy, imprecise handling. It causes the driver to constantly adjust steering input to compensate for this deflection and makes the car hard to drive. This compliance steering is caused by uncontrolled compliance of suspension components to lateral loads.

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Similarly, toe change occurs when the wheel encounters a bump and deflects the wheels from the intended track. This bump steer is caused by the vertical movement of the suspension arms rather than bushing compliance.

Standard solutions to these problems (extremely stiff bushing material, very high spring rates and hard damping) are effective to a great degree in controlling toe-change, but they produce a host of negative side effects such as poor bump absorption, stiffer than acceptable steering, ride harshness and poor steering feel. While this approach has been used in many exotics, it's a solution more appropriate to a race car but not considered acceptable for a new generation exotic like the NSX.

The solution adopted for the NSX was not to over-control wheel motion with excessive spring force and hard bushings, but rather to design in a beneficial amount of toe-change and deflection which would enhance handling and precision.

A key element to accomplishing this was the development of a compliance pivot. Like the other suspension components, this strut is an aluminum forging. It is used as the mounting point for the front pivots of both upper and lower control arms. Under vertical bump loads the compliance strut bushings are allowed to deflect a predetermined amount and allow the pivot to rotate minutely about its vertical axis. Because both control arms are attached to the pivot, the net effect of the pivot rotation is to allow both control arms to move rearward in unison maintaining static toe geometry throughout the control arms' vertical travel. Without the pivot, this static geometry and toe control would be difficult to maintain because the rate of deflection of the upper and lower control arm bushings would not necessarily be the same throughout the full wheel travel. With the compliance pivot, toe change is maintained at 0.2 Deg. toe-in at full compression and 0.2 Deg. toe-out at full rebound, a condition which ensures that the front wheels of the NSX will be unaffected by lateral or vertical loads and will track precisely to steering wheel input.

REAR SUSPENSION

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The rear also uses an upper and lower control arm design, coil over shock absorber, a lateral control arm and an anti-roll bar. The hub carrier is made of cast aluminum. The rear suspension is mounted on a cast aluminum sub-frame which is mounted to the chassis.

Like the front, the rear suspension is also subject to a certain amount of compliance and bump steer. They are subjected to torque loads imposed by the driveshafts which do create bushing and control arm deflection under acceleration, deceleration, cornering and braking.

To overcome this, the upper and lower control arm bushings and the geometry were optimized to produce desirable deflection under given conditions. Under braking, acceleration, and during suspension compression, toe change at the rear is allowed a small degree of toe-in. Under braking and acceleration, this toe-in enhances straight line stability. During cornering, controlled toe-in under compression yields quicker and more responsive turn-in and helps to steer the car through a corner.

Additionally, the suspension was optimized to enhance anti-dive under braking and anti-squat under acceleration.

The net result of the development program is a sports car which remains virtually neutral up to the limits, is without quirky handling behavior such as drop-throttle oversteer, and not only offers extremely high levels of lateral adhesion and responsiveness, but also makes the NSX easier to drive at the limit.

BRAKES

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It goes without saying, that a sports car needs brakes that can match or exceed the car's overall performance potential.

The NSX is equipped with 4-wheel ventilated disc brakes and dual piston steel calipers. The diameter of the front and rear discs are 282 mm (11.1 in.). Total brake swept area is 2960 sq cm and the swept area to weight ratio is 1966.8 sq cm/ton.

Aluminum calipers were considered, but their larger size, compared to steel, would have created the need for larger wheels which, in turn would have increased the amount of kingpin offset. Greater offset would have a negative impact on steering feel, kickback and ride quality. It was also found that aluminum calipers produced unfavorable side effects such as caliper flex and poor fade resistance.

The braking targets were to set new standards of braking performance, fade resistance, provide good pedal feel, linear braking response and low pedal effort. The development program was conducted both in the laboratory and on the Honda R&D Tochigi test track and the Suzuka and Tsubuka race circuits in Japan.

Also, during the lab and track testing, a new pad material was developed in conjunction with Akebono. At racing speeds, brake performance of this material surpassed the leading competitors by a significant margin.

NSX**CHASSIS****FOUR-CHANNEL ANTI-LOCK BRAKING SYSTEM**
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Developed by Honda R&D this newly developed 4-channel anti-lock braking system controls each wheel independently with a new 16-bit micro-processor. This four-wheel, independent capability allows much finer control of the anti-lock function especially when the car is braking on a surface with a split coefficient of friction — for instance if the left side wheels are on snow, ice or standing water and the right side wheels are on dry pavement. Applying maximum braking pressure in this situation, 4-channel anti-lock braking allows the driver to retain maximum directional stability and steering control for the given conditions.

The basic configuration is independent parallel hydraulic circuits. In addition to the primary, non-anti-lock braking circuit, the anti-lock system has its own hydraulic reservoir, pump, modulator unit, solenoids and control pistons. If a failure in the anti-lock braking hydraulic circuit should occur, normal braking force will be fully retained by the primary braking circuit.

This 4-channel system fully exploits the enhanced braking ability of the NSX's midship layout because the weight of the car is distributed nearly equally to each wheel.

The NSX is the only car available in the U.S. with a 4-channel anti-lock braking system.

VARIABLE RATIO RACK-AND-PINION STEERING SYSTEM

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NSX models with the manual transmission are equipped with a variable ratio manual, rack-and-pinion steering system. To ensure maximum reliability, it features a sealed gearbox design. Precise gear tooth engagement ensure linear progressive response to steering input. Steering wheel turns lock-to-lock are 3.2 and steering gear ratios vary from 18.2 to 20.8:1.

VARIABLE ELECTRIC POWER-ASSIST STEERING SYSTEM

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Available only on the automatic transmission-equipped NSX, this power-assist steering system is the first of its kind on the American market. The system consists of a rack-and-pinion steering gear with an electric motor installed concentrically around the steering rack. The motor transmits its power through a recirculating ball mechanism to the rack.

The rack-and-pinion steering rack is a direct unit which functions with no assist at higher vehicle speeds. The ECU receives signals from a speed sensor and, coupled with a steering sensor for torque and rotation, it then calculates the amount of assist and sends a signal to the motor.

The recirculating ball system provides the power assist to the rack. This simple, lightweight system requires no hydraulics and draws no power from the engine.

To ensure reliability, the electrical system for this unit features gold-plated connectors. The steering ratio is 18.6:1.

FORGED ALLOY WHEELS

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To further reduce unsprung weight and provide the highest strength possible, the engineers specified forged aluminum alloy wheels. The process is a three-stamp, dual-heat process. A billet of forged aluminum alloy is heated in an oil bath and then stamped. This procedure is repeated three times. The wheel is then spun to the final dimensions in a forming roller.

The result is a very light wheel with the strength and impact resistance of a heavier cast aluminum wheel. The rear wheels are 8x16 in. and the front wheels are 6.5x15 in. Compared to cast aluminum, the total weight savings of all four wheels amounts to 6 kg. (13.2 lbs.). The spare is cast aluminum, space saver type.

TIRES

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The goals for the tire chosen for the NSX went beyond the expected goals of excellent dry and wet weather traction and cornering ability. The suspension engineers, working in conjunction with Yokohama Rubber Co., Ltd., sought to produce a tire that would allow the driver to readily "feel" the limits of the tires' performance. This goal arose from the original concept that the NSX be a car that could easily be driven to the limit. In addition, the tire had to provide good durability, wear resistance, low noise level and good ride quality.

The two-year development period began with computerized simulations for creating the carcass and developing low-noise tread patterns. The actual work of refining the tire to provide superior feel required extensive track testing by professional drivers.

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As a result of this computer and track testing, the tires on the NSX are not only different sizes front at rear (205/50ZR15 front, and 225/50ZR16 rear) but they also feature a different tread block configuration and different compounds front and rear.

Called the AO22, the tires use a mixture of two compounds, the Tread Compound and the Undertread Compound. The Tread Compound contributes to wet and dry traction while the Undertread Compound contributes to handling stability, high speed stability and predictable reaction to steering input. The ideal "feel," response and traction for front and rear tires were accomplished by adjusting the ratio of these two basic compounds.

The belt material is a newly developed, highly pliant, small diameter filament which contributes to maintaining the shape of the contact patch under cornering and lane change maneuvers and also contributes to ride quality.

Using new technology recently developed for racing tires, a new sidewall and bead filler material were used in the AO22 tires. This produces a slightly harder sidewall which was fine-tuned from tread area to the the bead area and which contributed to the tire's ability to transmit information about the tire's limits to the driver.

To ensure high speed durability in excess of the car's actual top speed potential, a jointless belt cover was specially developed.

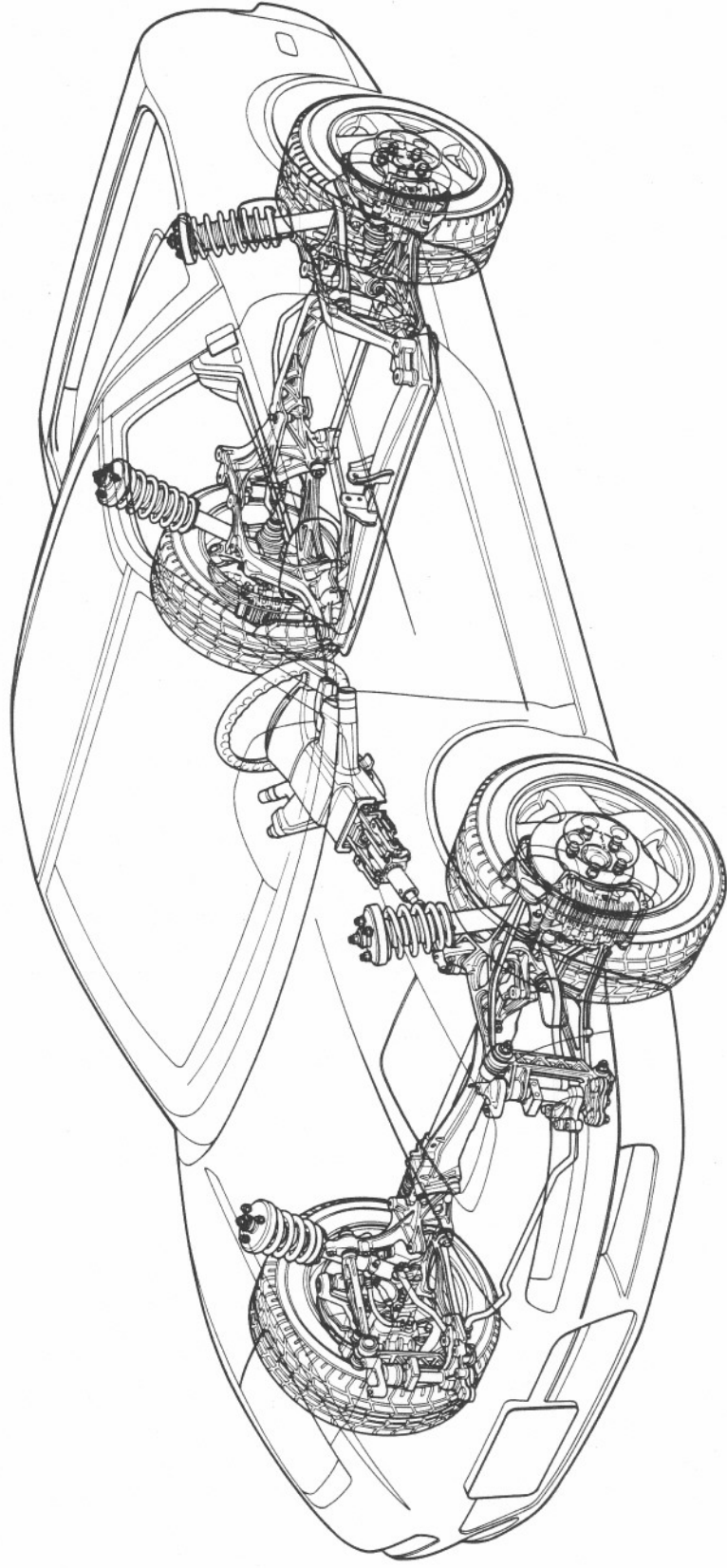
During the two-year development period, Yokohama produced and rejected ten separate molds and used more than 6000 test tires in over 100 different formulations of compound and construction before selecting the ideal final specification tire for the NSX.

NSX

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CHASSIS

SUSPENSION SYSTEM.....

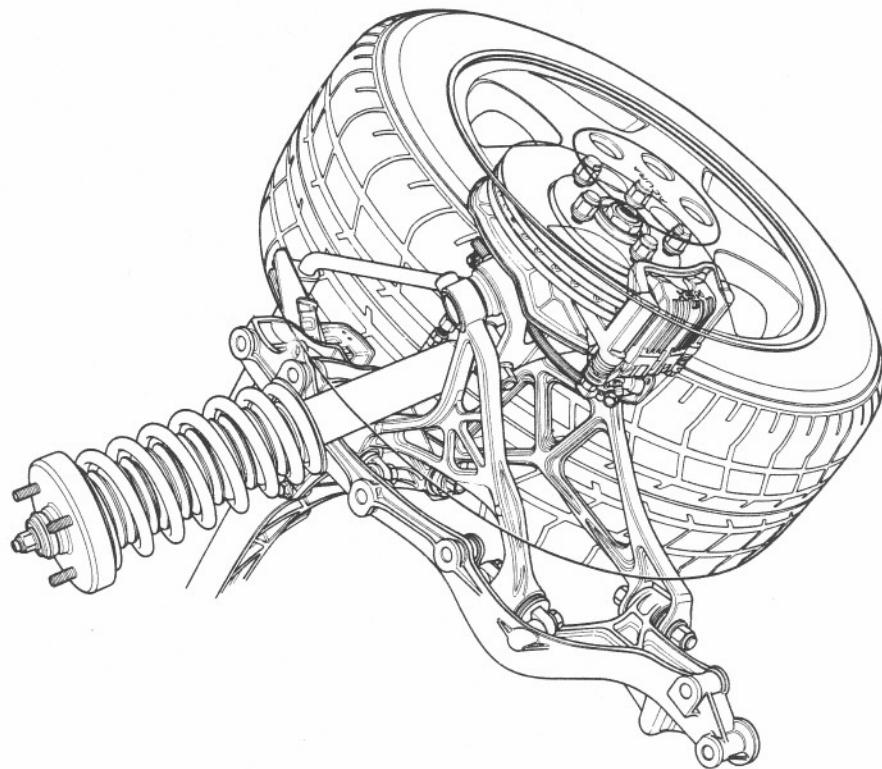


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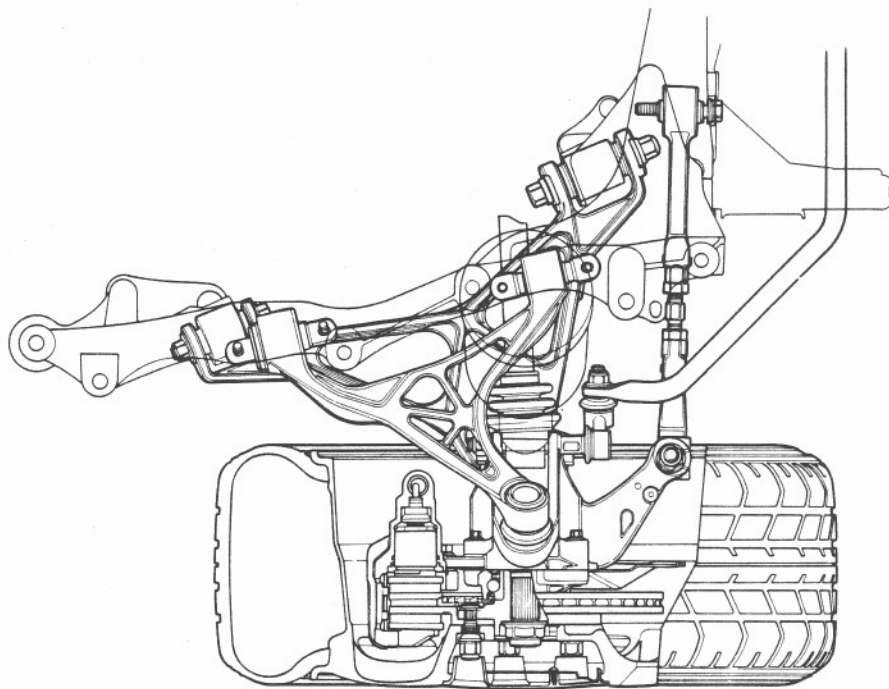
CHASSIS

NSX

REAR SUSPENSION



3/4 FRONT VIEW



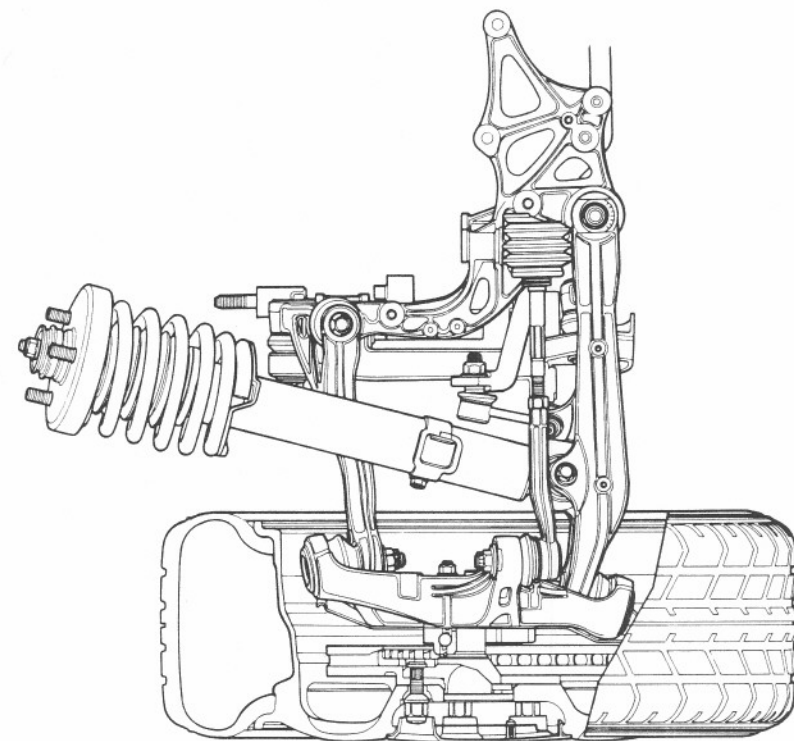
TOP VIEW

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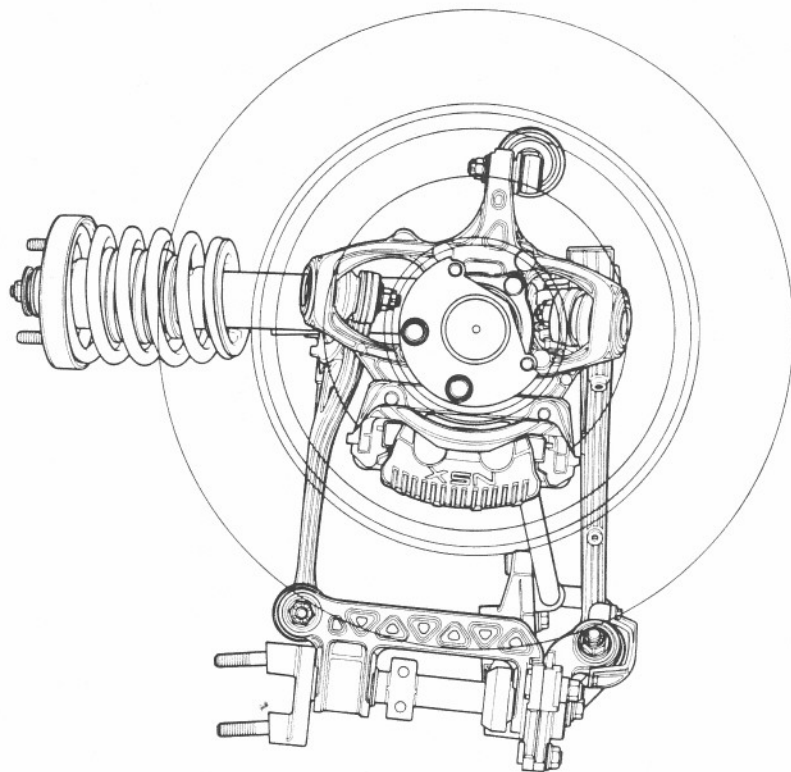
CHASSIS

NSX

FRONT SUSPENSION



REAR VIEW



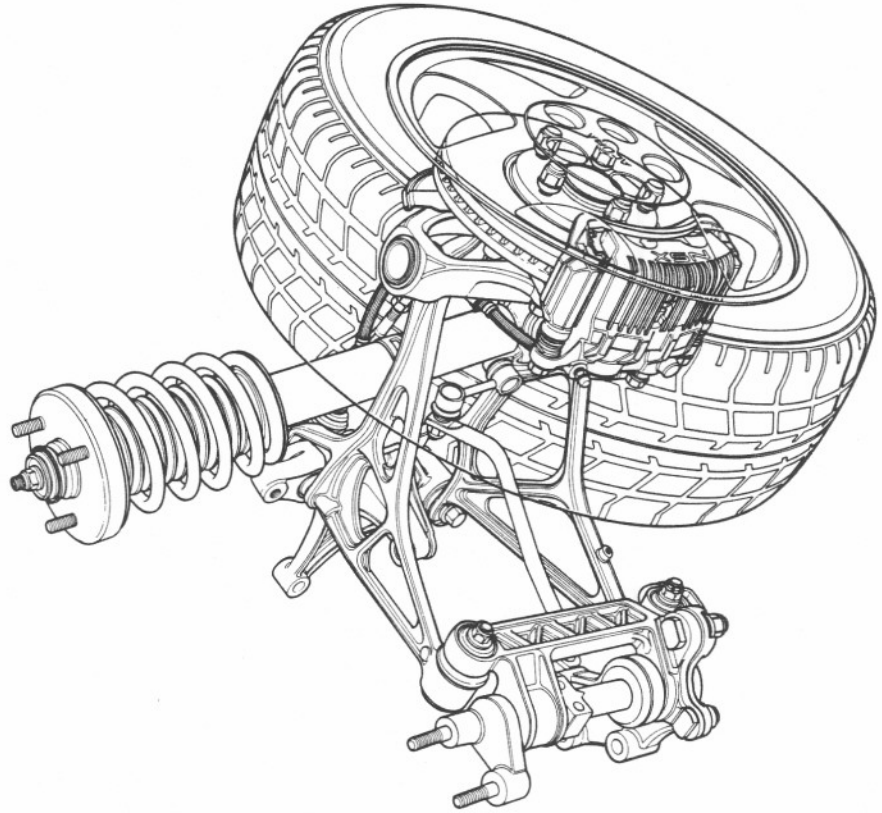
SIDE VIEW

NSX

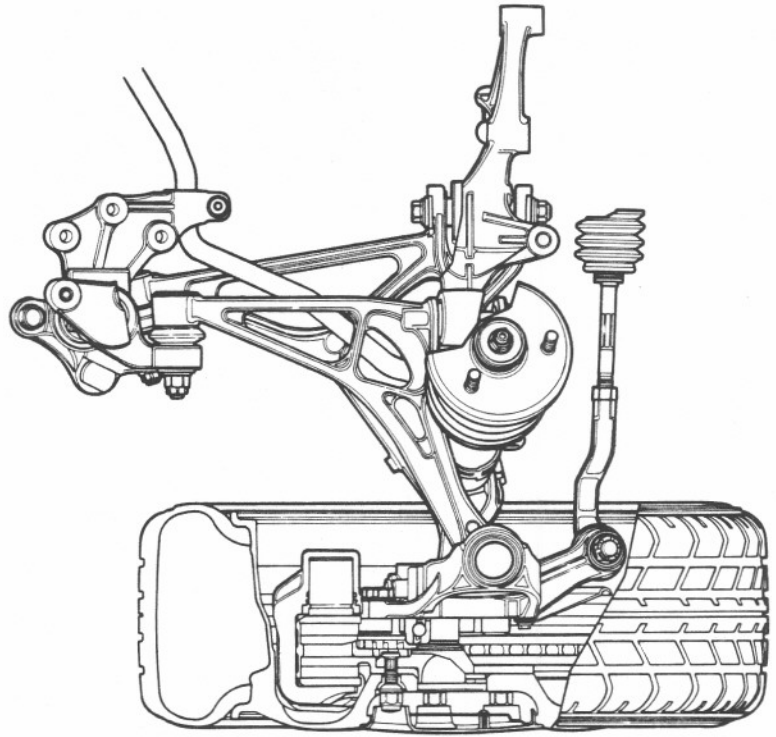
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CHASSIS

FRONT SUSPENSION



3/4 FRONT VIEW



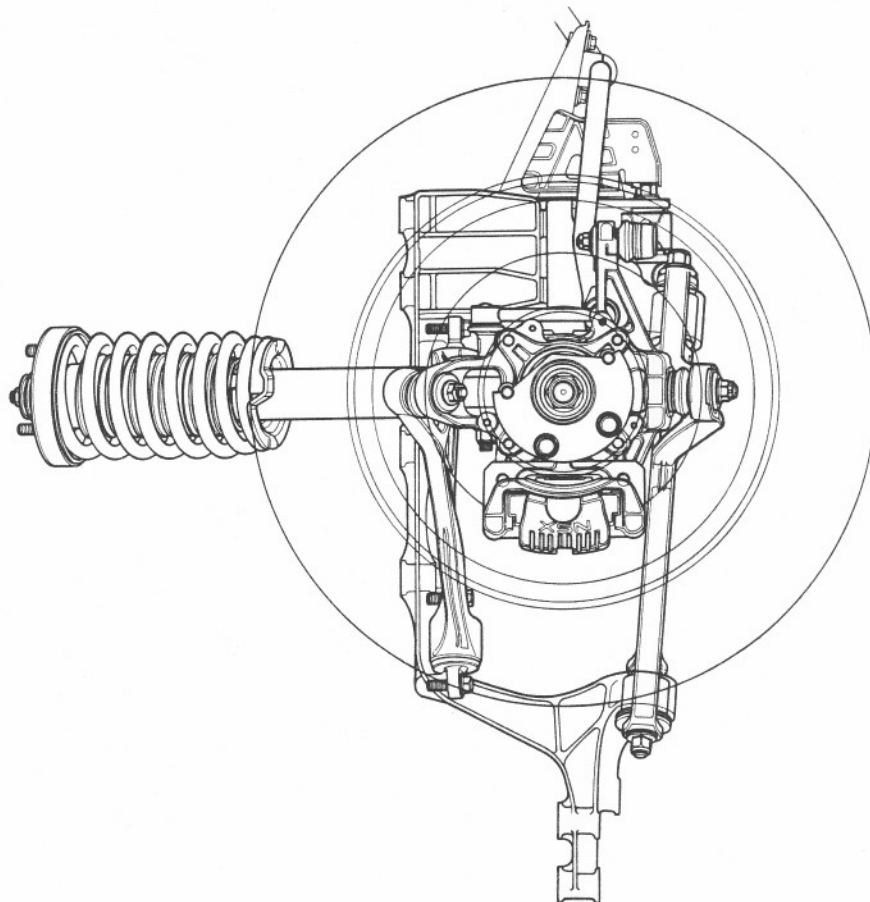
TOP VIEW

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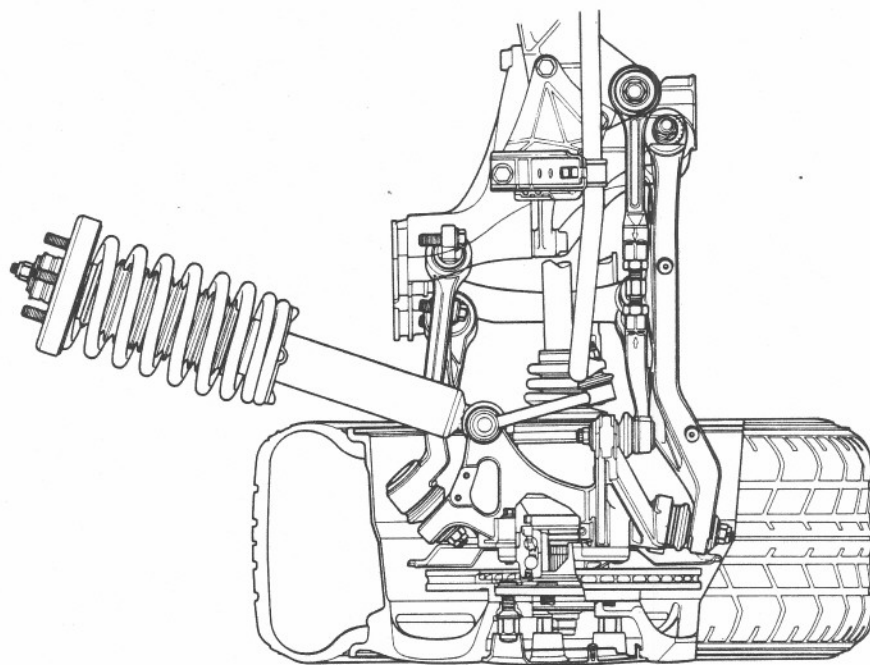
NSX

CHASSIS

REAR SUSPENSION



SIDE VIEW



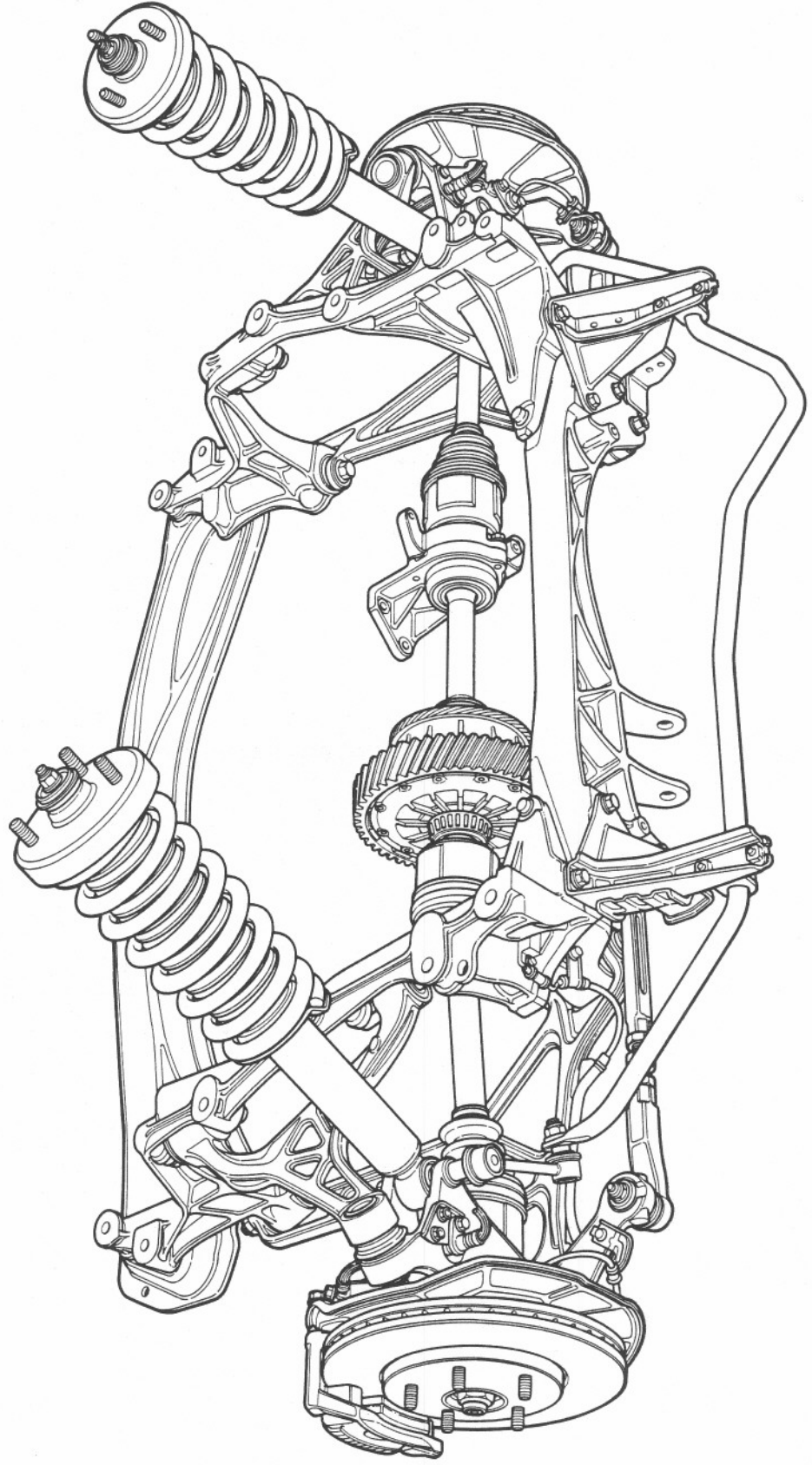
REAR VIEW

NSX

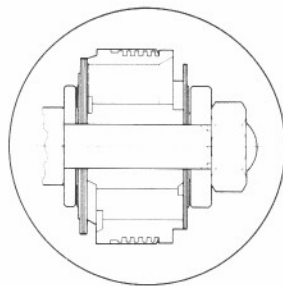
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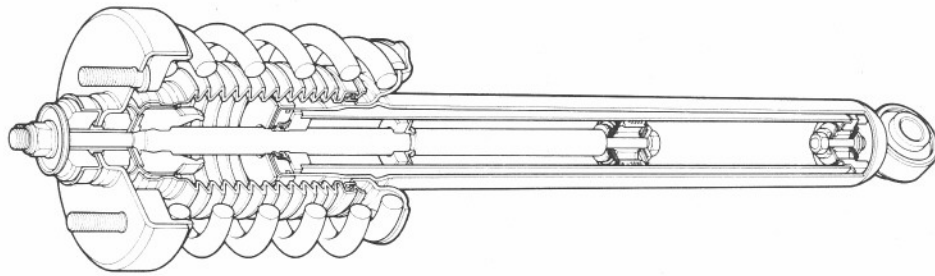
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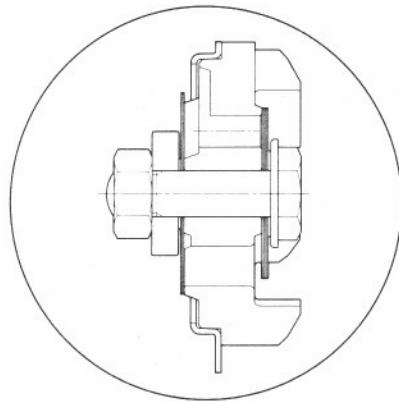
SHOCK ABSORBERS



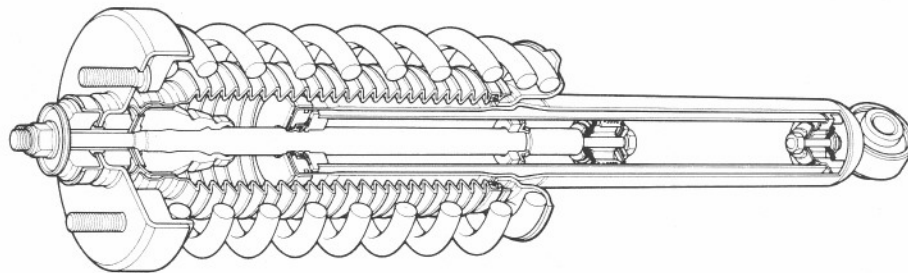
PISTON VALVE



FRONT SHOCK ABSORBER



BOTTOM VALVE



REAR SHOCK ABSORBER

VARIABLE ELECTRIC POWER ASSIST STEERING SYSTEM

